الهيئة القومية للبحث العلمي

السلوك الحراري للمنشآت

تصميمه وتنفيذه واقتصادياته

كمال الدين حسن

جلال محمد زكي

حسني يوسف الحمولي

السلوك الحراري للمنشآت

تحديده واقتصادياته

معهد الانماء العربي
ص. ب ١٤/٥٣٠٠
بيروت

الهيئة القومية للبحث العلمي
ص.ب ٨٠٠٤ ـ طرابلس
الجماهيرية العربية الليبية الشعبية الاشتراكية

الهيئة القومية للبحث العلمي

حسين يوسف الكموشي

السلوك الحراري للمنشآت

تحديده واقتصادياته

كمال الدين حسن
مركز دراسات الطاقة الشمسية

جلال محمد زكي
كلية الهندسة - جامعة الفاتح

طرابلس ١٩٨٢

مقدمة

التقرير المرفق هو التقرير النهائي عن المشروع البحثي بعنوان « حساب الاحمال الحرارية على المباني والمنشآت والاختيار الامثل لوحدات التبريد وتكييف الهواء ».

وقد اشترك في هذا المشروع عند بدئه الاخ/ الدكتور علي الشيباني على ان مسئولياته بعد أن ترك جامعة الفاتح جعلت من المستحيل استمراره في هذا المشروع بعد ان انتهى الفصل الثاني منه. وعلى هذا فقد استكمل المشروع بدون الاستفادة من تعاونه فيه.

والتقرير مقدم من جزئين: المتن والملاحق. والأخيرة كمية كبيرة حيث تحتوي على معلومات طلبت في العرض الأصلي للمشروع ولكنها ليست لازمه لتتبع المتن.

حسني يوسف الكموشي

ملخص

يتضح للعالم يوماً بعد يوم أن المصادر التقليديه للطاقه وخاصه النفط أثمن من أن تستغل كوقود فهي المادة الخام لصناعات رئيسية وهامة. وقد رفع هذا سعر هذه المصادر في السنين الاخيره واستوجب توفيرها واعادة دراسة استعمالاتها من جديد على ضوء الظروف الحالية. وقد واكب ذلك نداء عالمي بالاقتصاد في استعمال المصادر الحالية للطاقة والبحث عن مصادر جديده لها. على أن التجربة أثبتت ان الوعي الذي يستجيب لمثل هذا النداء ينتشر ببطء ولا يعطي الفاعلية المرجوة منه في وقت مناسب كما ان المصادر الجديدة للطاقة تحتاج الى تقنية هي ايضا جديدةوتحتاج الى وقت طويل لتثبيت اقدامها. على هذا، وحتى تثبت اقدام المصادر الجديدة للطاقة واهمها الطاقة الشمسية، فالأمل معقود على تحسين كفاءة الطرق الحالية لتحويل الطاقة وعلى الاقلال الجبري من استهلاكها بتغيير طرق التصميم.

والشمس وهي المصدر الاصلي للطاقة في هذا العالم، هي ايضا من أسباب ضياعها اذ تكون الحمل الحراري الاول على اغلب المنشئات التي تعمل في درجة حرارة اقل من درجة حرارة الجو المحيط بها مثل مخازن التبريد طوال السنة او المباني مكيفة الهواء في الصيف وقد جعل هذا حساب الحمل الحراري من الشمس والجو المحيط بمثل تلك المباني من اهم الموضوعات في هندسة التبريد وتكييف الهواء.

على ان الظروف التي سادت حتى وقت قريب والتي تتلخص في رخص الطاقة بالنسبة للأيدي العاملة، جعل الطرق التي استنبطت لحساب الاحمال الحرارية تستهدف السهولة قبل الدقة حتى تصبح في متناول التقنيين ذوي الثقافة المتوسطة وغير الهندسية. على ان تغير الموازنه بين تكاليف الطاقة وتكاليف الايدي العامله الذي ساد العالم في الفتره الاخيره يستدعي اعادة النظر في طرق الحساب الموجودة لاستبدالها بطرق اخرى اكثر دقة من ناحية وتشمل نظرة اقتصادية واضحة نحو تصميم المباني من ناحية أخرى.

وهذا التقرير هو محاولة لدراسة موضوع استهلاك الطاقة لاغراض تكييف الهواء واعادة النظر في الطرق المستخدمه حالياً.

ويشمل الفصل الاول العلاقات الرياضية العامة التي تحدد السلوك الحراري للمباني ومنها أمكن ايجاد علاقات رياضيه للتشابه بين المباني ونماذجها التجريبية مما يمكن معه تمثيل وتوقع الاحمال الحرارية وتحديد تأثير الاجهزة الحرارية لمبنى والتي قد تستخدم فيه اجهزة تعمل بالطاقة الشمسية.

والفصل الثاني عباره عن دراسة عن تحديد الانسياب الحراري خلال حائط بسيط (سقف - حائط جنوبي ، غربي ،...) تكون من طبقة واحدة من مادة واحدة وعلى الرغم من ان محتوى هذا الفصل يغطي الحالة الخاصة والتي تكون فيها درجة الحرارة داخل المباني ثابتة فان التعبيرات الرياضية المستخدمة ذات طبيعة عامة مما يمكن معه استخدامها في حالات اخرى منها التحكم في كمية الحرارة المنتقلة الى المبنى او درجة حرارته الداخلية او كليهما معا.

ومما يضيف الى مرونة التحليل الرياضي المستخدم في هذا الفصل تحديد العوامل المختلفة التي تؤثر في كمية الحرارة المنتقلة خلال الحوائط وذلك بفصل تأثير درجة حرارة الجو الخارجي عن تأثير اشعة الشمس الساقطه على الواجهات المختلفة للمبنى. وكذلك تم فصل كمية الحراره المنتقلة خلال الحوائط الى جزئين احدهما ثابت لا يتغير مع الزمن وهذا يعين الطاقة الضرورية في اليوم وجزء آخر متغير مع الزمن ويعين اقصى حمل متوقع على اجهزة تكييف الهواء كنتيجة للعوامل الخارجيه (سقوط اشعة الشمس ودرجة حرارة الجو الخارجي).

والفصل الثالث امتداد للدراسة السابقة في الباب الثاني يشمل حوائط مركبة من اكثر من طبقة من مواد مختلفة قد تكون مواد بناء عادية (طوب - حجارة - خرسانة...) ومواد عازلة حراريا (اسبستس - فلين ،...) ومواد مختلفه (جبس - محارة ،...).

وتقع الدراسة الاقتصادية والاختيار الامثل لحوائط المباني في الباب الرابع حيث يتم تعيين كل من التكاليف الثابتة وتكاليف التشغيل السنوية لمبنى مكيف الهواء درجة حرارته الداخلية ثابتة مع الاخذ في الاعتبار الحمل الحراري السابق حسابه في الفصلين الثاني والثالث ونوعية النشاط داخل المبنى واتجاه حوائط المبنى... الخ. وقد اقترحت طريقة لايجاد أمثل اختيار للحوائط للحصول على اقل مجموع للتكاليف السنوية.

وفي الفصل الخامس والاخير اختبرت هذه الطريقة بمثال عددي لمخزن بارد وتم تحديد نوعية وسمك جدران هذا المخزن.

ويحتوي الجزء الثاني من هذا التقرير على برنامج الحاسب الآلي الذي وضع لهذا المشروع وطريقة استعماله مع بعض المعلومات عن خواص مواد البناء والعزل الحراري.

0.2000 0.0100 1.3300 0.3720 0.30200E-02 0.60000E-03
0.10000E 01 0.78947E 00 0.28226E 01 0.10244E 01 0.26015E 01
0.16435E 01 0.32653E 00

B16-4 S(CR---GY)

0.0	-0.73467E-01	-0.34435E 00	-0.41782E 00	0.84644E 00
0.20000E01	-0.22760E-01	0.38598E-01	0.15839E-01	0.12801E 01
0.40000E01	0.27064E-01	0.70694E 09	0.73409E 00	0.19983E 01
0.60090E01	0.60693E-01	0.10797E 01	0.11404E 01	0.24047E 01
0.80000E01	0.76607E-01	0.97519E 00	0.10518E 01	0.23160E 01
0.10000E02	0.72666E-01	0.44924W 00	0.52190E 00	0.17862E 01
0.12000E02	0.49619E-01	-0.25667E 00	-0.20705E 00	0.10572E 01
0.14000E02	0.10421E-01	-0.62571E 00	-0.61529E 00	0.64896E 00
0.16000E02	-0.23401E-01	-0.58470E 00	-0.60810E 00	0.65615E 00
0.18000E02	-0.44458E-01	-0.52954E-00	-0.57399E 00	0.69026E 00
0.20000E02	-0.60626E-01	-0.48017E-00	-0.54991E 09	0.71334E 00
0.21000E01	-0.71816E-01	-0.31579E- 0	-0.-49861E 00	0.75565E 00
0.14000E01	-0.73354E-01	-0.34433E 00	-0.41789E 00	0.84545E 00

AVERAGE AND MAX. FLUX = 0.12643E 01 0.23047E 01

9.1000 0.0100 1.3300 0.3710 0.30200E-01 0.60000E-03
0.10000E 01 0.41353E 00 0.14785E 01 0.10244E 01 0.26015E 01
0.59901E 01 0.11901E 01

B16-2 S(CR---GY)

0.0	-0.10969E 00	-0.46071E00	-0.57040E00	0.88318E00
0.20000E01	-0.99046E-02	0.32465E00	0.31474E00	0.17683E01
0.40000E01	0.65398E-01	0.13960E01	0.14614E01	0.29150E01
0.60000E01	0.11130E 00	0.18124E01	0.19237E01	0.33772E01
0.80000E01	0.12672E 00	0.14298E01	0.15565E01	0.30101E01
0.10000E02	0.11069E 00	0.42756E00	0.53825E00	0.19918E01
0.12000E02	0.64526E-01	-0.72589E00	-0.66136E00	0.79222E00
0.14000E02	-0.42400E-02	-0.10991E01	-0.11034E01	0.35022E00
0.16000E02	-0.52664E-01	-0.93096E00	-0.98362E00	0.46996E00
0.18000E02	-0.81053E-01	-0.82088E00	-0.90193E00	0.55165E00
0.20000E02	-0.10312E 00	-0.72431E00	-0.82743E00	0.62615E00
0.22000E02	-0.11978E 00	-0.61810E00	-0.73788E00	0.71570E00
0.24000E02	-0.10969E 00	-0.46067E00	-0.57036E00	0.88322E00

AVERAGE AND MAX. FLUX = 0.14536E 01 0.33772E 01

0.1500 0.0100 1.3300 0.3720 0.30200E-02 0.60000E-03
0.10000E 01 0.60150E 00 0.21505E 01 0.10244E 01 0.26015E 01
0.28312E 01 0.56250E 00

B16-3 S(CR---GY)

0.0	-0.85871E-01	-0.37061E00	-0.55648E00	0.89584E00
0.20000E01	-0.14319E-01	0.18374E00	0.16942E00	0.15217E01
0.40000E01	0.44915E-01	0.10057E01	0.10506E01	0.24030E01
0.60000E01	0.82187E-01	0.13716E01	0.14538E01	0.28061E01
0.80000E01	0.96494E-01	0.11317E01	0.12282E01	0.25805E01
0.10000E02	0.86446E-01	0.40226E00	0.48870E00	0.18410E01
0.12000E02	0.53219E-01	-0.47736E00	-0.42414E00	0.92818E00
0.14000E02	0.19521E-02	-0.82557E00	-0.82362E00	0.52870E00
0.16000E02	-0.36976E-01	-0.72064E00	-0.75762E00	0.59470E00
0.18000E02	-0.60146E-01	-0.63919E00	-0.69934E00	0.62599E00
0.20000E02	-0.77904E-01	-0.56744E00	-0.64534E00	0.70698E00
0.22000E02	-0.91021E-01	-0.48831E00	-0.57933E00	0.77299E00
0.24000E02	-0.85868E-01	-0.37059E00	-0.45664E00	0.89587E00

AVERAGE AND MAX. FLUX 0.13523E 01 0.28061E 01

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.1500	0.3720	0.13300	0.600003-03	0.30200e-02

NH BINO BINI NKO NKI FOO FOI

0.10000E 01 0.21505E 01 0.60150E 00 0.26015E 01 0.10244E 01
0.56250E 00 0.28313E 01

B15-3 S(GY---CR)

0.0	-0.85871E-01	-0.37061E00	-0.45648E00	0.89558E00
0.20000E01	-0.14319E-01	0.18374E00	0.16942E00	0.15217E01
0.40000E01	0.44916E-01	0.10057E01	0.10506E01	0.24030E01
0.60000E01	0.82187E-01	0.13716E01	0.14538E01	0.28061E01
0.80000E01	0.96494E-01	0.11317E01	0.12282E01	0.25805E01
0.10000E02	0.86446E-01	0.40226E00	0.48870E00	0.18410E01
0.12000E02	0.53220E-01	-0.47736E00	-0.42414E00	0.92818E00
0.14000E02	0.19520E-02	-0.82557E00	-0.82362E00	0.52870E00
0.16000E02	-0.36976E-01	-0.72064E00	-0.75762E00	0.59470E00
0.18000E02	-0.60146E-01	-0.63919E00	-0.69934E00	0.65299E00
0.20000E02	-0.77904E-01	-0.56744E00	-0.64534E00	0.70698E00
0.22000E02	-0.91021E-02	-0.48831E00	-0.57933E00	0.77299E00
0.24000E02	-0.85868E-01	-0.37059E00	-0.45645E00	0.89587E00

AVERAGE AND MAX. FLUX = 0.13523E 01 0.28061E 01

LO	LI	KO	KI	A20	
0.0500	0.0100	0.3300	0.3720	0.30200E-02	0.60000E-03

0.10000E 01 0.22556E 00 0.80645E 00 0.10244E 01 0.26015E 01
0.20133E 02 0.40000E 01

B16-1 S(CR---GY)

TIME	QT	QR	QU	IT
0.0	-0.15833E 00	-0.72723E00	-0.88576E00	0.68547E00
0.20000E01	-0.23577E-01	0.33139E00	0.30782E00	0.78790E01
0.40000E01	0.80077E-01	0.18329E01	0.19129E01	0.34842E01
0.60000E01	0.14618E 00	0.24748E01	0.26210E01	0.41922E01
0.80000E01	0.17204E 00	0.20286E01	0.22007E01	0.37719E01
0.10000E02	0.15515E 00	0.70111E00	0.85627E00	0.24275E01
0.12000E02	0.95864E-01	-0.89332E00	-0.79746E00	0.77378E00
0.14000E02	0.27929E-02	-0.14416E01	-0.14388E01	0.13245E00
0.16000E02	-0.64079E-01	-0.12466E01	-0.13106E01	0.26058E00
0.18000E02	-0.10485E 00	-0.11249E01	-0.12298E01	0.34144E00
0.20000E02	-0.13818E 00	-0.10183E01	-0.11565E01	9.41473E00
0.11999E92	-0.16565E 00	-0.90110E00	-0.10668E01	0.50448E00
0.14099E91	-9.15853E 99	-0.71717E00	-9.78579E99	9.58553E00

AVERAGEANDMAX.FLUX=0.15711E910.41912E01

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.0500	0.3720	1.3300	0.60000e-03	0.30200e-02

NH	BINO	BINI	NKO	NKI	FOO	FOI

0.10000E 01 0.80645E 00 0.22556E 00 0.26015E 01 0.10244E 01
0.40000E 01 0.20133E 02

B15-1 S(GY---CR)

0.0	-0.15853E 00	-0.72723E00	-0.88576E00	0.68547E00
0.20000E01	-0.23577E-01	0.33139E00	0.30782E00	0.18790E01
0.40000E01	0.80077E-01	0.18329E01	0.19129E01	0.34842E01
0.60000E01	0.14618E 00	0.24748E01	0.26210E01	0.41922E01
0.80000E01	0.17204E 00	0.20286E01	0.22007E01	0.37719E01
0.10000E02	0.15515E 00	0.70111E00	0.85627E00	0.24275E01
0.12000E02	0.95864E-01	-0.89332E00	-0.79746E00	0.77377E00
0.14000E02	0.27928E-02	-0.14416E01	-0.14388E01	0.13245E00
0.16000E02	-0.64079E-01	-0.12466E01	-0.13106E01	0.26058E00
0.18000E02	-0.10485E 00	-0.11249E01	-0.12298E01	0.34144E00
0.20000E02	-0.13818E 00	-0.10183E01	-0.11565E01	0.41473E00
0.220000E02	-0.1656E 00	-0.90110E00	-0.10668E01	0.50448E00
0.240000E02	-0.1583E 00	-0.72717E00	-0.88570E00	0.68553E00

AVERAGE AND MAX. FLUX = 0.15712E 01 0.41922E 01

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.1000	0.3720	1.3300	0.60000e-03	0.30200e-02

NH	BINO	BINI	NKO	NKI	FOO	FOI

0.10000E 01 0.14785E 01 0.41353E 00 0.26015E 01 0.10244E 01
0.11901E 01 0.59901E 01

B15-2 S(GY---CR)

0.0	-0.10969E 00	-0.56071E00	-0.57040E00	0.88318E00
0.20000E01	-0.99047E-02	0.32465E00	0.31474E00	0.17683E01
0.40000E01	0.65398E-01	0.13960E01	0.14614E01	0.29150E01
0.60000E01	0.11130E 00	0.18124E01	0.19237E01	0.33772E01
0.80000E01	0.12672E 00	0.14298E01	0.15565E01	0.30101E01
0.10000E02	0.11069E 00	0.42756E00	0.53825E00	0.19918E01
0.12000E02	0.64526E-01	-0.72588E00	-0.56136E00	0.79222E00
0.14000E02	-0.42400E-02	-0.10991E01	-0.11034E01	0.35022E00
0.16000E02	-0.52664E-01	-0.93096E00	-0.98362E00	0.46996E00
0.18000E02	-0.81053E-01	-0.82088E00	-0.90193E00	0.55165E00
0.20000E02	-0.10312E 00	-0.72431E00	-0.82743E00	0.62615E00
0.22000E02	-0.11978E 00	-0.61810E00	-0.73788E00	0.71570E00
0.24000E02	-0.10969E 00	-0.46067E00	-0.57036E00	0.88322E00

AVERAGE AND MAX. FLUX = 0.14536E 01 0.33772E 01

LO	LI	KO	KI	ALFAU	ALFAI
0.1500	0.0100	0.5600	0.1000	0.16722e-02	0.71200e-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	0.14006E 01	0.78432E 01	0.30752E 01	0.41062E 02	0.15677E 01	0.66750E 00

A1-2-7 S(AS---BR)

TIME		QT	QR	QU	TOTAL
0,0	-0.55779E-01	-0.40599E 00	-0.46177E 00	0.49768E00	
0.20000E01	-0.22764E-01	-0.88321E-01	-0.11108E 00	0.84836E00	
0.40000E01	0.54378E-02	0.40688E 00	0.41232E 00	0.13718E01	
0.60000E01	0.27092E-01	0.67348E 00	0.70057E 00	0.16600E01	
0.80000E01	0.41228E-01	0.62749E 00	0.66872E 00	0.16282E01	
0.10000E02	0.45351E-01	0.31717E 00	0.36252E 00	0.13220E01	
0.12000E02	0.37191E-01	-0.87692E-01	-0.50512E-01	0.90894E00	
0.14000E02	0.17059E-01	-0.22822E 00	-0.21116E 00	0.74829E00	
0.16000E02	0.10662E-03	-0.20524E 00	-0.20513E 00	0.75432E00	
0.18000E02	-0.14483E-01	-0.25810E 00	-0.27258E 00	0.68687E00	
0.20000E02	-0.31668E-01	-0.34060E 00	-0.37226E 00	0.58718E00	

LO	LI	KO	KI	ALFAU	ALFAI
0.2000	0.0100	0.5600	0.1000	0.16722e-02	0.71200e-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	0.1832E 01	0.10294E 02	0.30752E 01	0.41062E 02	0.91004E 00	0.38748E 00

A1-2-8 S(AS---BR)

TIME		QT	QR	QU	TOTAL
0.0	-0.46192E-01	-0.30863E 00	-0.35482E 00	0.50560E00	
0.20000E01	-0.23266E-01	-0.84780E-01	-0.10805E 00	0.75238E00	
0.40000E01	0.14966E-02	0.29605E 00	0.29755E 00	0.11580E01	
0.60000E01	0.21692E-01	0.53664E 00	0.55833E 00	0.14188E01	
0.80000E01	0.35534E-01	0.54198E 00	0.57751E 00	0.14379E01	
0.10000E02	0.40273E-01	0.32826E 00	0.36853E 00	0.12290E01	
0.12000E02	0.34356E-01	0.49687E-02	0.39324E-01	0.89975E00	
0.14000E02	0.17897E-01	-0.18158E 00	-0.16369E 00	0.69674E00	
0.16000E02	0.87582E-03	-0.21338E 00	-0.21251E 00	0.64792E00	
0.18000E02	-0.13617E-01	-0.26422E 00	-0.27784E 00	0.58259E00	
0.20000E02	-0.28170E-01	-0.31515E 00	-0.34332E 00	0.51711E00	
0.22000E02	-0.41128E-01	-0.33874E 00	-0.37986E 00	0.48056E00	

LO	LI	KO	KI	ALFAU	ALFAI
0.0500	0.0100	0.5600	0.1000	0.16722e-02	0.71200e-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	0.52521E 00	0.29412E 01	0.30752E 01	0.41062E 02	0.11148E 02	0.4767E 01

A1-2-5 S(AS---BR)

TIME		QT	QR	QU	TOTAL
0.0	-0.89419E-01	-0.71098E00	-0.80040E00	0.44589E00	
0.20000E01	-0.28297E-01	-0.17402E00	-0.30232E00	0.94398E00	
0.40000E01	0.15946E-01	0.62118E00	0.63713E00	0.18834E01	
0.60000E01	0.44708E-01	0.11147E01	0.11594E01	0.24057E01	
0.80000E01	0.60527E-01	0.10208E01	0.10813E01	0.23276E01	
0.10000E02	0.62242E-01	0.41372E00	0.47597E00	0.17223E01	
0.12000E02	0.46750E-01	-0.37685E00	-0.33010E00	0.91619E00	
0.14000E02	0.12889E-01	-0.52659E00	-0.51370E00	0.73259E00	
0.16000E02	-0.62777E-02	-0.26714E00	-0.27342E00	0.97288E00	
0.18000E02	-0.16814E-01	-0.20259E00	-0.21941E00	0.10269E01	
0.20000E02	-0.36425E-01	-0.29962E00	-0.33605E00	0.91024E00	
0.22000E02	-0.67714E-01	-0.50182E00	-0.56953E00	0.67676E00	

LO	LI	KO	KI	ALFAU	ALFAI
0.1000	0.0100	0.5600	0.1000	0.16722e-02	0.71200e-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	0.96289E 00	0.53922E 01	0.30752E 01	0.41062E 02	0.33168E 01	0.14122E 01

A1-2-6 S(AS---BR)

TIME		QT	QR	QU	TOTAL
0.0	-0.69917E-01	-0.54650E00	-0.61641E00	0.46780E00	
0.20000E01	-0.23646E-01	-0.13940E00	-0.16305E00	0.92117E00	
0.40000E01	0.10456E-01	0.52799E00	0.53845E00	0.16227E01	
0.60000E01	0.34502E-01	0.86639E00	0.90089E00	0.19851E01	
0.80000E01	0.49043E-01	0.77409E00	0.82313E00	0.19073E01	
0.10000E02	0.52163E-01	0.32812E00	0.38028E00	0.14645E01	
0.12000E02	0.40907E-01	-0.22150E00	-0.18059E00	0.90363E00	
0.14000E02	0.15335E-01	-0.32848E00	-0.31315E00	0.77107E00	
0.16000E02	-0.17090E-02	-0.20750E00	-0.20921E00	0.87501E00	
0.18000E02	-0.15063E-01	-0.23183E00	-0.24690E00	0.83732E00	
0.20000E02	-0.34471E-01	-0.34105E00	-0.37552E00	0.70870E00	
0.22000E02	-0.58846E-01	-0.47321E00	-0.53205E00	0.55217E90	

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.1500	0.1000	0.5600	0.71800E-03	0.16722E-02

TIME QT QR QU TOTAL

0.10000E 01 0.78431E 01 0.14006E 01 0.41408E 02 0.30752E 01
0.67313E 00 0.15677E 01

A1-2-3 S(AS---BR)

TIME	QT	QR	QU	TOTAL
0.0	-0.85364E-01	-0.62120E00	-0.70657E 00	0.25288E00
0.20000E02	-0.34858E-01	-0.13527E00	-0.17013E 00	0.78932E00
0.40000E01	0.83095E-02	0.62248E00	0.63079E 00	0.15902E01
0.60000E01	0.41460E-01	0.10306E01	0.10721E 01	0.20315E01
0.80000E01	0.63101E-01	0.96044E00	0.10235E 01	0.19830E01
0.10000E02	0.69415E-01	0.48571E00	0.55512E	0.15146E01
0.12000E02	0.56931E-01	-0.13389E00	-0.76955E-01	0.88249E00
0.14000E01	0.25121E-01	-0.24930E00	-0.32318E 00	0.63627E00
0.16000E02	0.16426E-03	-9.31431E00	-0.31414E 90	9.64530E00
0.18000E02	-0.22172E-01	-0.39519E00	-0.41736E 09	0.54108E00
0.29000E01	-0.48479E-01	-0.52134E90	-0.56981E 00	0.38964E90
0.22900E02	-0.75662E-91	-0.61189E00	-0.69855E	

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.2000	0.1000	0.5600	0.71800e-03	0.16722e-02
NH	BINO	BINI	NKO	NKI	FOO	FOI

0.10000E 01 0.10294E 02 0.1832E 01 0.41408E 02 0.30752E 01
0.39075E 00 0.91004E 00

A1-2-4 S(AS---BR)

TIME	QT	QR	QU	TOTAL
0.0	-0.70705E-01	-0.47235E 00	-0.54063E 00	0.31737E00
0.20000E01	-0.35634E-01	-0.12997E 00	-0.16560E 00	0.69483E00
0.40000E01	0.22775E-02	0.45290E 00	0.45518E 00	0.13156E01
0.60000E01	0.33198E-01	0.82135E 00	0.85455E 00	0.17150E01
0.80000E01	0.54393E-01	0.82974E 00	0.88413E 00	0.17446E01
0.10000E02	0.61652E-01	0.50276E 00	0.56441E 00	0.14248E01
0.12000E02	0.52599E-01	0.78672E-02	0.60466E-01	0.92089E00
0.14000E02	0.27406E-01	-0.27800E 00	-0.25060E	0.60983E00
0.16000E02	0.13429E-02	-0.32679E 00	-0.32544E 00	0.53498E00
0.18000E02	-0.20844E-01	-0.40454E 00	-0.42538E 00	0.43504E00
0.20000E02	-0.43118E-01	-0.48239E 00	-0.52550E 00	0.33492E00
0.22000E02	-0.62947E-01	-0.51842E 00	-0.58137E 00	0.27906E00

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.0500	0.1000	0.5600	0.71800E-03	0.16722E-02

TIME	QT	QR	QU	TOTAL
0.10000E 01	0.29412E 01	0.52521E 00	0.41408E 02	0.30752E 01
0.47867E 01	0.11148E 02			

A1-2-1 S(AS---BR)

	TIME	QT	QR	QU	TOTAL
0.0	00	-0.10877E01	-0.12245E01	0.21813E-01	
0.20000E01	-0.43291E-01	-0.41912E00	-0.46241E00	0.78388E 00	
0.40000E01	0.24392E-01	0.95036E00	0.97476E00	0.22210E 01	
0.60000E01	0.68396E-01	0.17053E01	0.17737E01	0.30200E 01	
0.80000E01		0.15616E01	0.16542E01	0.29005E 01	
0.10000E92	0.95225E-01	0.63294E00	0.72816E09	0.19745E 01	
0.12000E02	0.71525E-01	-0.57644E00	-0.50492E00	0.74138E 00	
0.14000E02	0.19724E-01	-0.80551E00	-0.78578E00	0.46051E 00	
0.16000E02	-0.96003E-02	-0.40868E00	-0.41828E00	0.82802E 00	
0.18000E02	-0.25724E-01	-0.31002E00	-0.33574E00	0.91055E 00	
0.20000E02	-0.55731E-91	-0.45850E00	-0.51423E00	0.73206E 00	
0.22000E02	-0.10360E 00	-0.76780E00	-0.87140E00	0.37489E 00	

LO	LI	KO	KI	ALFAU	ALFAI
0.0100	0.1000	0.1000	0.5600	0.71800E-03	0.16722E-02

TIME	QT	QR	QU	TOTAL
0.10000E 01	0.53922E 01	0.96289E 00	0.41408E 02	0.30752E 01
0.14241E 01	0.33168E 01			

A1-2-2 S(AS---BR)

	TIME	QT	QR	QU	TOTAL
0.0	-0.10698E 00	-0.83608E00	-0.94306E00	0.14116E 00	
0.20000E01	-0.36193E-01	-0.21323E00	-0.24943E00	0.83479E 00	
0.40000E01	0.15990E-01	0.80781E00	0.82380E00	0.19080E 01	
0.60000E01	0.52790E-01	0.13256E01	0.13784E01	0.24626E 01	
0.80000E01	0.75048E-01	0.11845E01	0.12595E01	0.23437E 01	
0.10000E92	0.79826E-01	0.50225E00	0.58208E00	0.16663E 01	
0.12000E02	0.62606E-01	-0.33836E00	-0.27602E00	0.80820E 00	
0.14000E02	0.23478E-91	-0.50253E00	-0.47905E00	0.50517E 00	
0.15000E02	-0.26121E-02	-0.31765E00	-0.32026E00	0.76396E 00	
0.18000E02	-0.23057E-01	-0.35497E00	-0.37803E00	0.70619E 00	
0.20000E02	-0.52757E-01	-0.52204E00	-0.57480E00	0.50942E 00	
0.22000E02	-0.90046E-01	-0.71412E00	-0.81416E00	0.27006E 00	

L0	L1	K0	K1	ALFA0	ALFA1
0.1500	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13882E 01	0.21787E 02	0.33512E 01	0.18690E 03	0.17391E 01	0.39375E 00

A1-1-7 S(BR---CO)

	TIME	QT	QR	QU	TOTAL
0.0	-0.39395E-01	-0.28965E 00	-0.32904E 00	0.45349E00	
0.20000E01	-0.15679E-01	-0.63288E-01	-0.78967E-01	0.70356E00	
0.40000E01	0.41246E-02	0.28979E 00	0.29392E 00	0.10764E01	
0.60000E01	0.19185E-01	0.47751E 00	0.49670E 00	0.12792E01	
0.80000E01	0.28936E-01	0.44170E 00	0.47064E 00	0.12532E01	
0.10000E02	0.31702E-01	0.21817E 00	0.24987E 00	0.10324E01	
0.12000E02	0.25860E-01	-0.70177E-01	-0.44316E-01	0.73821E00	
0.14000E02	0.11621E-01	-0.16338E 00	-0.15176E 00	0.63077E00	
0.16000E02	-0.35722E-04	-0.14085E 00	-0.14089E 00	0.64165E00	

L0	L1	K0	K1	ALFA0	ALFA1
0.2000	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.18220E 01	0.28595E 02	0.33512E 01	0.18690E 03	0.10095E 01	0.22857E 00

A1-1-8 S(BR---CO)

	TIME	QT	QR	QU	TOTAL
0.0	-0.32817E-01	-0.22249E 00	-0.25530E 00	0.46063E00	
0.20000E01	-0.15979E-01	-0.58117E-01	-0.74096E-01	0.64183E00	
0.40000E01	0.14383E-02	0.21588E 00	0.21732E 00	0.93325E00	
0.60000E01	0.15515E-01	0.38394E 00	0.39946E 00	0.11154E01	
0.80000E01	0.25096E-01	0.38213E 00	0.40722E 00	0.11232E01	
0.10000E02	0.28305E-01	0.22505E 00	0.25335E 00	0.96928E00	
0.12000E02	0.23995E-01	-0.57216E-02	0.18273E-01	0.73420E00	
0.14000E02	0.12273E-01	-0.12953E 00	-0.11726E 00	0.59867E00	
0.16000E02	0.53060E-03	-0.14634E 00	-0.14581E 00	0.57012E00	
0.18000E02	-0.95018E-02	-0.18209E 00	-0.19159E 00	0.52434E00	
0.20000E02	-0.19826E-01	-0.22057E 00	-0.24040E 00	0.47553E00	
0.22000E02	-0.29242E-01	-0.24094E 00	-0.27019E 00	0.44574E00	

L0	L1	K0	K1	ALFA0	ALFA1
0.0500	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1
0.10000E 01 0.52057E 00 0.81700E 01 0.33512E 01 0.18690E 03
0.12367E 02 0.28000E 01

A1-1-5 S(BR---CO)

TIME	QT	QR	QU	TOTAL
0.0	-0.61622E-01	-0.48944E	00-0.55106E00	0.41035E00
0.20000E01	-0.19518E-01	-0.19138E	00-0.21190E00	0.74951E00
0.40000E01	0.11029E-01	0.42522E	00 0.43625E00	0.13977E01
0.60000E01	0.30836E-01	0.76794E	00 0.79878E00	0.17602E01
0.80000E01	0.41685E-01	0.70521E	00 0.74690E00	0.17083E01
0.10000E02	0.42808E-01	0.28655E	00 0.32935E00	0.12908E01
0.12000E02	0.32099E-01	-0.26137E	00-0.22927E00	0.73213E00
0.14000E02	0.87079E-02	-0.36688E	00-0.35818E00	0.60323E00
0.16000E02	-0.44849E-02	-0.18559E	00-0.19007E00	0.77133E00
0.18000E02	-0.11564E-01	-0.13768E	00-0.14924E00	0.81216E00
0.20000E02	-0.24885E-01	-0.20229E	00-0.22718E00	0.73423E00
0.22000E02	-0.46955E-01	-0.34182E	00-0.38821E00	0.57320E00

L0	L1	K0	K1	ALFA0	ALFA1
0.1000	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1
0.10000E 01 0.95437E 00 0.14978E 02 0.33512E 01 0.18690E 03
0.36793E 01 0.83306E 00

A1-1-6 S(BR---CO)

TIME	QT	QR	QU	TOTAL
0.0	-0.48890E-01	-0.38361E00	-0.43250E00	0.43030E00
0.20000E01	-0.16353E-01	-0.10094E00	-0.11729E00	0.74551E00
0.40000E01	0.74748E-02	0.36820E00	0.37568E00	0.12385E01
0.60000E01	0.24148E-01	0.60661E00	0.63075E00	0.14935E01
0.80000E01	0.34155E-01	0.54175E00	0.57590E00	0.14387E01
0.10000E02	0.36221E-01	0.22734E00	0.26366E00	0.11264E01
0.12000E02	0.28297E-01	-0.16044E00	-0.13215E00	0.73065E00
0.14000E02	0.10381E-01	-0.23364E00	-0.22326E00	0.63954E00
0.16000E02	-0.13465E-02	-0.14363E00	-0.14498E00	0.71782E00
0.18000E02	-0.10371E-01	-0.15695E00	-0.16732E00	0.69548E00
0.20000E02	-0.23748E-01	-0.23242E00	-0.25617E00	0.60662E00
0.22000E02	-0.40857E-01	-0.32718E00	-0.36803E00	0.49467E00

L0	L1	K0	K1	ALFA0	ALFA1
0.0100	0.1500	0.0360	0.5650	0.42000E-03	0.18550E-02

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.21787E 02	0.13882E 01	0.18690E 03	0.33512E 01	0.39375E 00	0.17391E 01

A1-1-3 S(C0---BR)

TIME	QT	QR	QU	TOTAL
0.0	-0.82792E-01	-0.60872E00	-0.69151E 00	0.91018E-01
0.20000E01	-0.32950E-01	-0.13301E00	-0.16595E 00	0.61658E 00
0.40000E01	0.86682E-02	0.60903E00	0.61770E 00	0.14002E 01
0.60000E01	0.40319E-01	0.10035E01	0.10439E	0.18264E 01
0.80000E01	0.60812E-01	0.92827E00	0.98908E 00	0.17716E 01
0.10000E02	0.66624E-01	0.45850E00	0.52512E 00	0.13077E 01
0.12000E02	0.54348E-01	-0.14748E00	-0.93136E-01	0.68939E 00
0.14000E02	0.24422E-01	-0.34336E00	-0.31894E 00	0.46360E 00
0.16000E02	-0.75024E-04	-0.29601E00	-0.29608E 00	0.48645E 00
0.18000E02	-0.21048E-01	-0.36981E00	-0.39086E 00	0.39167E 00
0.20000E02	-0.46324E-01	-0.49438E00	-0.54070E 00	0.24183E 00
0.20000E02	-0.73064E-01	-0.60050E00	-0.67357E 00	0.10896E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.0100	0.2000	0.0360	0.5650	0.42000E-03	0.18550E-02

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.28595E 02	0.18220E 01	0.18690E 03	0.33512E 01	0.22857E 00	0.10095E 01

A1-1-4 S(BR---CO)

TIME	QT	QR	QU	TOTAL
0.0	-0.68957E-01	-0.46757E 00	-0.53654E 00	0.17939E00
0.20000E01	-0.33580E-01	-0.12214E 00	-0.15572E 00	0.56021E00
0.40000E01	0.30228E-02	0.45370E 00	0.45672E 00	0.11726E01
0.60000E01	0.32606E-01	0.80689E 00	0.83950E 00	0.15554E01
0.80000E01	0.52742E-01	0.80308E 00	0.85582E 00	0.15717E01
0.10000E02	0.59485E-01	0.47296E 00	0.53245E 00	0.12484E01
0.12000E02	0.50428E-01	-0.12025E-01	0.38403E-01	0.75433E00
0.14000E02	0.25793E-01	-0.27222E 00	-0.24642E 00	0.46950E00
0.16000E02	0.11151E-02	-0.30754E 00	-0.30642E 00	0.40950E00
0.18000E02	-0.19969E-01	-0.38267E 00	-0.40264E 00	0.31329E00
0.20000E02	-0.41666E-01	-0.46355E 00	-0.50512E 00	0.21071E00
0.22000E02	-0.61455E-01	-0.50636E 00	-0.56782E 00	0.14811E00

L0	L1	K0	K1	ALFA0	ALFA1
0.0100	0.0500	0.0360	0.5650	0.42000E-03	0.18550E-02

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.81700E 01	0.52057E 00	0.18690E 03	0.33512E 01	0.28000E 01	0.12367E 02

A1-1-1 S(C0---BR)

TIME	QT	QR	QU	TOTAL
0.0	-0.12950E 00	-0.10286E01	-0.11581E01	-0.19670E 00
0.20000E01	-0.41019E-01	-0.40431E00	-0.44533E00	0.51608E 00
0.40000E01	0.23179E-01	0.89363E00	0.91681E00	0.18782E 01
0.60000E01	0.64804E-01	0.16139E01	0.16787E01	0.26401E 01
0.80000E01	0.87605E-01	0.14821E01	0.15697E01	0.25311E 01
0.10000E02	0.89965E-01	0.60220E00	0.69217E00	0.16536E 01
0.12000E02	0.67458E-01	-0.54930E00	-0.48184E00	0.47957E 00
0.14000E02	0.18300E-01	-0.77104E00	-0.75274E00	0.20867E 00
0.16000E02	-0.94254E-02	-0.39003E00	-0.39946E00	0.56195E 00
0.18000E02	-0.24304E-01	-0.28935E00	-0.31365E00	0.64776E 00
0.20000E02	-0.52298E-01	-0.42513E00	-0.47743E00	0.48398E 00
0.22000E02	-0.97503E-01	-0.71835E00	-0.81586E00	0.14555E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.0100	0.1000	0.0360	0.5650	0.42000E-03	0.18550E-02

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.14978E 02	0.9547E 00	0.18690E 03	0.33512E 01	0.83306E 00	0.36793E 01

A1-1-2 S(CO---BR)

TIME	QT	QR	QU	TOTAL
0.0	-0.10275E 00	-0.80618E00	-0.90893E00	-0.46136E-01
0.20000E01	-0.34368E-01	-0.21213E00	-0.24649E00	0.61630E 00
0.40000E01	0.15709E-01	0.77381E00	0.78952E00	0.16523E 01
0.60000E01	0.50750E-01	0.12748E01	0.13256E01	0.21884E 01
0.80000E01	0.71779E-01	0.11385E01	0.12103E01	0.20731E 02
0.10000E02	0.76121E-01	0.47777E00	0.55389E00	0.14167E 01
0.12000E02	0.59468E-01	-0.33719E00	-0.27772E00	0.58508E 00
0.14000E02	0.21818E-01	-0.49102E00	-0.46920E00	0.39360E 00
0.16000E02	-0.28298E-02	-0.30185E00	-0.30468E00	0.55811E 00
0.18000E02	-0.21797E-01	-0.32984E00	-0.35163E00	0.51116E 00
0.20000E02	-0.49908E-01	-0.48846E00	-0.53837E00	0.32442E 00
0.22000E02	-0.85865E-01	-0.68759E00	-0.77346E00	0.89336E-01

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45983E 01	0.72168E 02	0.33512E 01	0.18690E 03	0.15849E 00	0.35885E-01

B5-4-10 S(BR---CO)

0.0	-0.15232E-01	-0.11664E 00	-0.13187E 00	0.14941E00
0.20000E01	-0.16645E-01	-0.11331E 00	-0.12996E 00	0.15132E00
0.40000E01	-0.10117E-01	-0.40217E-01	-0.50334E-01	0.23095E00
0.60000E01	-0.10085E-02	0.85648E-01	0.84640E-01	0.36592E00
0.80000E01	0.75088E-02	0.18805E 00	0.19555E 00	0.47684E00
0.10000E02	0.13446E-01	0.21399E 00	0.22744E 00	0.50872E00
0.12000E02	0.15743E-01	0.14736E 00	0.16310E 00	0.44438E00
0.14000E02	0.13616E-01	0.21152E-01	0.34767E-01	0.31605E00
0.16000E02	0.73693E-02	-0.64037E-01	-0.56668E-01	0.22461E00
0.18000E02	0.66001E-03	-0.97766E-01	-0.97106E-01	0.18417E00
0.20000E02	-0.51414E-02	-0.11011E 00	-0.11525E 00	0.16603E00
0.22000E02	-0.10146E-01	-0.11442E 00	-0.12457E 00	0.15671E00

AVERAGE AND MAX. FLUX = 0.28128E 00 0.50872E 00

L0	L1	K0	K1	ALFA0	ALFA1
4800	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45983E 01	0.72168E 02	0.33512E 01	0.18690E 03	0.15849E 00	0.35885E-01

B5-4-10 S(BR---CO)

0.0	-0.15232E-01	-0.11664E 00	-0.13187E 00	0.14941E00
0.20000E01	-0.16645E-01	-0.11331E 00	-0.12996E 00	0.15132E00
0.40000E01	-0.10117E-01	-0.40217E-01	-0.50334E-01	0.23095E00
0.60000E01	-0.10085E-02	0.85648E-01	0.84640E-01	0.36592E00
0.80000E01	0.75088E-02	0.18805E 00	0.19555E 00	0.47684E00
0.10000E02	0.13446E-01	0.21399E 00	0.22744E 00	0.50872E00
0.12000E02	0.15743E-01	0.14736E 00	0.16310E 00	0.44438E00
0.14000E02	0.13616E-01	0.21152E-01	0.34767E-01	0.31605E00
0.16000E02	0.73693E-02	-0.64037E-01	-0.56668E-01	0.22461E00
0.18000E02	0.66001E-03	-0.97766E-01	-0.97106E-01	0.18417E00
0.20000E02	-0.51414E-02	-0.11011E 00	-0.11525E 00	0.16603E00
0.22000E02	-0.10146E-01	-0.11442E 00	-0.12457E 00	0.15671E00

AVERAGE AND MAX. FLUX = 0.28128E 00 0.50872E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.45550E 01 0.71487E 02 0.33512E 01 0.18690E 03
0.16152E 00 0.36571E-01

B5-4-9 S(BR---CO)

0.0	-0.16255E-01	-0.12313E 00	-0.13939E 00	0.15747E00
0.20000E01	-0.17623E-01	-0.11920E 00	-0.13683E 00	0.16003E00
0.40000E01	-0.10525E-01	-0.40240E-01	-0.50764E-01	0.24610E00
0.60000E01	-0.79268E-03	0.94074E-01	0.93281E-01	0.39014E00
0.80000E01	0.82189E-02	0.20186E 00	0.21008E 00	0.50694E00
0.10000E02	0.14425E-01	0.22731E 00	0.24174E 00	0.53860E00
0.12000E02	0.16738E-01	0.15425E 00	0.17098E 00	0.46784E00
0.14000E02	0.14345E-01	0.18936E-01	0.33281E-01	0.33014E00
0.16000E02	0.76098E-02	-0.70634E-01	-0.63024E-01	0.23384E00
0.18000E02	0.47242E-03	-0.10512E 00	-0.10464E 00	0.19222E00
0.20000E02	-0.56502E-02	0.11725E 00	-0.12290E 00	0.17396E00
0.22000E02	-0.10906E-01	-0.12119E 00	-0.13210E 00	0.16476E00

AVERAGE AND MAX. FLUX = 0.29686E 00 0.53860E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.45983E 01 0.72168E 02 0.33512E 01 0.18690E 03
0.15849E 00 0.35885E-01

B5-4-10 S(BR---CO)

0.0	-0.15232E-01	-0.11664E 00	-0.13187E 00	0.14941E00
0.20000E01	-0.16645E-01	-0.11331E 00	-0.12996E 00	0.15132E00
0.40000E01	-0.10117E-01	-0.40217E-01	-0.50334E-01	0.23095E00
0.60000E01	-0.10085E-02	0.85648E-01	0.84640E-01	0.36592E00
0.80000E01	0.75088E-02	0.18805E 00	0.19555E 00	0.47684E00
0.10000E02	0.13446E-01	0.21399E 00	0.22744E 00	0.50872E00
0.12000E02	0.15743E-01	0.14736E 00	0.16310E 00	0.44438E00
0.14000E02	0.13616E-01	0.21152E-01	0.34767E-01	0.31605E00
0.16000E02	0.73693E-02	-0.64037E-01	-0.56668E-01	0.22461E00
0.18000E02	0.66001E-03	-0.97766E-01	-0.97106E-01	0.18417E00
0.20000E02	-0.51414E-02	-0.11011E 00	-0.11525E 00	0.16603E00
0.22000E02	-0.10146E-01	-0.11442E 00	-0.12457E 00	0.15671E00

AVERAGE AND MAX. FLUX = 0.28128E 00 0.50872E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.44682E 01 0.70126E 02 0.33512E 01 0.18690E 03
0.16786E 00 0.38006E-01

B5-4-7 S(BR---CO)

0.0	-0.18738E-01	-0.13852E 00	-0.15725E 00	0.17659E 00
0.20000E01	-0.19948E-01	-0.13303E 00	-0.15298E 00	0.18086E 00
0.40000E01	-0.11418E-01	-0.39408E-01	-0.50826E-01	0.28302E 00
0.60000E01	-0.172650-03	0.11548E 00	0.11530E 00	0.44915E 00
0.80000E01	0.10006E-01	0.23580E 00	0.24581E 00	0.57965E 00
0.10000E02	0.16819E-01	0.25920E 00	0.27602E 00	0.60986E 00
0.12000E02	0.19122E-01	0.16981E 00	0.18893E 00	0.52277E 00
0.14000E02	0.16047E-01	0.12236E-01	0.28283E-01	0.36212E 00
0.16000E02	0.81059E-02	-0.87328E-01	-0.79223E-01	0.25462E 00
0.18000E02	-0.55176E-04	-0.12303E 00	-0.12309E 00	0.21075E 00
0.20000E02	-0.69296E-02	-0.13435E 00	-0.14128E 00	0.19257E 00
0.22000E02	-0.12767E-01	-0.13727E 00	-0.15004E 00	0.18381E 00

AVERAGE AND MAX. FLUX = 0.33384E 00 0.60986E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.45116E 01 0.70807E 02 0.33512E 01 0.18690E 03
0.16465E 00 0.37278E-01

B5-4-8 S(BR---CO)

0.0	-0.17414E-01	-0.13038E 00	-0.14780E 00	0.16647E00
0.20000E01	-0.18717E-01	-0.12574E 00	-0.14446E 00	0.16981E00
0.40000E01	-0.10959E-01	-0.40010E-01	-0.50969E-01	0.26330E00
0.60000E01	-0.52037E-03	0.10389E 00	0.10337E 00	0.41764E00
0.80000E01	0.90418E-02	0.21764E 00	0.22668E 00	0.54094E00
0.10000E02	0.15540E-01	0.24228E 00	0.25782E 00	0.57209E00
0.12000E02	0.17856E-01	0.16172E 00	0.17958E 00	0.49384E00
0.14000E02	0.15152E-01	0.16045E-01	0.31197E-01	0.34546E00
0.16000E02	0.78571E-02	-0.78308E-01	-0.70450E-01	0.24382E00
0.18000E02	0.23894E-03	-0.11347E 00	-0.11323E 00	0.20104E00
0.20000E02	-0.62396E-02	-0.12527E 00	-0.13151E 00	0.18276E00
0.22000E02	-0.11771E-01	-0.12876E 00	-0.14053E 00	0.17374E00

AVERAGE AND MAX. FLUX = 0.31427E 00 0.57209E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.43814E 01	0.68764E 02	0.33512E 01	0.18690E 03	0.17457E 00	0.39526E-01

B5-4-5 S(BR---CO)

0.0	-0.22037E-01	-0.15811E 00	-0.18014E 00	0.20121E00
0.20000E 01	-0.22928E-01	-0.15039E 00	-0.17332E 00	0.20803E00
0.40000E 01	-0.12380E-01	-0.36251E-01	-0.48631E-01	0.33272E00
0.60000E 01	0.86752E-03	0.14611E 00	0.14698E 00	0.52832E00
0.80000E 01	0.12518E-01	0.28176E 00	0.29428E 00	0.67563E00
0.10000E 02	0.20031E-01	0.30048E 00	0.32051E 00	0.70186E00
0.12000E 02	0.22221E-01	0.18780E 00	0.21002E 00	0.59137E00
0.14000E 02	0.18152E-01	0.30519E-03	0.18457E-01	0.39981E00
0.16000E 02	0.85659E-02	-0.11095E 00	-0.10239E 00	0.27896E00
0.18000E 02	-0.91606E-03	-0.14691E 00	-0.14782E 00	0.23353E00
0.20000E 02	-0.87263E-02	-0.15651E 00	-0.16524E 00	0.21611E00
0.22000E 02	-0.15278E-01	-0.15785E 00	-0.17313E 00	0.20822E00

AVERAGE AND MAX. FLUX = 0.38135E 00 0.70186E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.44248E 01	0.69445E 02	0.33512E 01	0.18690E 03	0.17116E 00	0.38754E-01

B5-4-6 S(BR---CO)

0.0	-0.20262E-01	-0.14769E 00	-0.16795E 00	0.18806E00
0.20000E01	-0.21342E-01	-0.14120E 00	-0.16254E 00	0.19348E00
0.40000E01	-0.11895E-01	-0.38249E-01	-0.50144E-01	0.30587E00
0.60000E01	0.27719E-03	0.12932E 00	0.12959E 00	0.48561E00
0.80000E01	0.11147E-01	0.25693E 00	0.26807E 00	0.62409E00
0.10000E02	0.18299E-01	0.27845E 00	0.29675E 00	0.65276E00
0.12000E02	0.20565E-01	0.17852E 00	0.19908E 00	0.55510E00
0.14000E02	0.17043E-01	0.71580E-02	0.24201E-01	0.38022E00
0.16000E02	0.83472E-02	-0.98052E-01	-0.89704E-01	0.26631E00
0.18000E02	-0.43048E-03	-0.13407E 00	-0.13450E 00	0.22152E00
0.20000E02	-0.77466E-02	-0.14467E 00	-0.15242E 00	0.20360E00
0.22000E02	-0.13923E-01	-0.14689E 00	-0.16082E 00	0.19520E00

AVERAGE AND MAX. FLUX = 0.35602E 00 0.65276E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42947E 01	0.67402E 02	0.33512E 01	0.18690E 03	0.18170E 00	0.41139E-01

B5-4-3 S(BR---CO)

0.0	-0.26612E-01	-0.18369E 00	-0.21031E 00	0.23431E00
0.20000E01	-0.26823E-01	-0.17255E 00	-0.19937E 00	0.24525E00
0.40000E01	-0.13260E-01	-0.27649E-01	-0.40908E-01	0.40371E00
0.60000E01	0.27216E-02	0.19288E 00	0.19560E 00	0.64022E00
0.80000E01	0.16250E-01	0.34690E 00	0.36315E 00	0.80776E00
0.10000E02	0.24525E-01	0.35522E 00	0.37975E 00	0.82437E00
0.12000E02	0.26364E-01	0.20723E 00	0.23359E 00	0.67821E00
0.14000E02	-0.20758E-01	-0.22091E-01	-0.13337E-02	0.44328E00
0.16000E02	0.88164E-02	-0.14605E 00	-0.13723E 00	0.30739E00
0.18000E02	-0.24056E-02	-0.17984E 00	-0.18225E 00	0.26237E00
0.20000E02	-0.11391E-01	-0.18613E 00	-0.19752E 00	0.24710E00
0.22000E02	-0.18822E-01	-0.18493E 00	-0.20376E 00	0.24086E00

AVERAGE AND MAX. FLUX = 0.44462E 00 0.82437E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.43380E 01	0.68083E 02	0.33512E 01	0.18690E 03	0.17808E 00	0.40320E-01

B5-4-4 S(BR---CO)

0.0	-0.24124E-01	-0.17001E 00	-0.19413E 00	0.21643E00
0.20000E01	-0.24741E-01	-0.16079E 00	-0.18553E 00	0.22503E00
0.40000E01	-0.12849E-01	-0.32963E-01	-0.45812E-01	0.36475E00
0.60000E01	0.16545E-02	0.16682E 00	0.16848E 00	0.57904E00
0.80000E01	0.14187E-01	0.31131E 00	0.32550E 00	0.73606E00
0.10000E02	0.22078E-01	0.32586E 00	0.34794E 00	0.75850E00
0.12000E02	0.24135E-01	0.19749E 00	0.22162E 00	0.63218E00
0.14000E02	0.19387E-01	-0.90706E-02	0.10317E-01	0.42088E00
0.16000E02	0.87365E-02	-0.12667E 00	-0.11793E 00	0.29263E00
0.18000E02	-0.15539E-02	-0.16198E 00	-0.16354E 00	0.24703E00
0.20000E02	-0.99179E-02	-0.17019E 00	-0.18011E 00	0.23045E00
0.22000E02	-0.16887E-01	-0.17041E 00	-0.18730E 00	0.22326E00

AVERAGE AND MAX. FLUX = 0.41056E 00 0.75850E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42079E 01	0.66041E 02	0.33512E 01	0.18690E 03	0.18927E 00	0.42853E-01

B5-4-1 S(BR---CO)

0.0	-0.33302E-01	-0.21788E 00	-0.25119E 00	0.28188E 00
0.20000E01	-0.31916E-01	-0.20042E 00	-0.23234E 00	0.30072E 00
0.40000E01	-0.13520E-01	-0.49221E-02	-0.18442E-01	0.51462E 00
0.60000E01	0.62691E-02	0.27033E 00	0.17660E 00	0.809663 00
0.80000E01	0.22164E-01	0.44378E 00	0.46594E 00	0.99901E 00
0.10000E02	0.31118E-01	0.42846E 00	0.45958E 00	0.99264E 00
0.12000E02	0.32057E-01	0.22321E 00	0.25526E 00	0.78833E 00
0.14000E02	0.23874E-01	-0.66710E-01	-0.42836E-01	0.49013E 00
0.16000E02	0.83645E-02	-0.20067E 00	-0.19231E 00	0.34075E 00
0.18000E02	-0.51694E-02	-0.22702E 00	-0.23219E 00	0.30088E 00
0.10000E02	-0.15629E-01	-0.12734E 00	-0.24297E 00	0.29009E 00
0.12000E02	-0.24126E-01	-0.22187E 00	-0.14600E 90	0.28706E 00

AVERAGE AND MAX. FLUX = 0.53396E 00 0.99901E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42513E 01	0.66722E 02	0.33512E 01	9.18690E 03	0.18542E 00	0.41983E-01

B5-4-2 S(BR---CO)

9.0	-0.29617E-01	-0.19953E 00	-0.22914E 00	0.25569E00
0.20000E01	-0.29210E-01	-0.18580E 00	-0.21501E 00	0.26983E00
0.40000E01	-0.13533E-01	-0.19050E-01	-0.32582E-01	0.45226E00
0.69000E01	0.41954E-02	0.22635E 00	0.23055E 00	0.71539E00
0.80000E01	0.18844E-01	0.39030E 00	0.40915E 00	0.89398E00
0.10000E02	0.27488E-01	0.38925E 00	0.41674E 00	0.90158E00
0.12000E02	0.28978E-01	0.21629E 00	0.24527E 00	0.73011E00
0.14000E02	0.22262E-01	-0.40457E-01	-0.18195E-01	0.46664E00
0.16000E02	0.87332E-02	-0.17024E 00	-0.16150E 00	0.32334E00
0.18000E02	-0.35637E-02	-0.20120E 00	-0.20476E 00	0.28008E00
0.20000E02	-0.13244E-01	-0.20490E 00	-0.21814E 00	0.26670E00
0.22000E02	-0.21186E-01	-0.20187E 00	-0.22306E 00	0.26178E00

AVERAGE AND MAX. FLUX = 0.48484E 00 0.90158E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.35138E 01 0.55147E 02 0.33512E 01 0.18690E 03
0.27142E 00 0.61454E-01

B5-3-9 S(BR---CO)

0.0	-0.20033E-01	-0.13149E 00	-0.15152E 00	0.17281E00
0.20000E01	-0.18848E-01	-0.11517E 00	-0.13402E 00	0.19031E00
0.40000E01	-0.80487E-02	0.21236E-02	-0.59251E-02	0.31841E00
0.60000E01	0.37280E-02	0.16229E 00	0.16602E 00	0.49036E00
0.80000E01	0.13291E-01	0.26298E 00	0.27627E 00	0.60060E00
0.10000E02	0.18712E-01	0.25359E 00	0.27230E 00	0.59663E00
0.12000E02	0.19276E-01	0.13341E 00	0.15268E 00	0.47701E00
0.14000E02	0.14354E-01	-0.35447E-01	-0.21093E-01	0.30324E00
0.16000E02	0.51305E-02	-0.11741E 00	-0.11228E 00	0.21205E00
0.18000E02	-0.31022E-02	-0.13806E 00	-0.14161E 00	0.18317E00
0.20000E02	-0.95835E-02	-0.14058E 00	-0.15016E 00	0.17417E00
0.22000E02	-0.14774E-01	-0.13681E 00	-0.15158E 00	0.17275E00

AVERAGE AND MAX. FLUX = 0.32433E 00 0.60060E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.35572E 01 0.55828E 02 0.33512E 01 0.18690E 03
0.26484E 00 0.59964E-01

B5-3-10 S(BR---CO)

0.0	-0.18788E-01	-0.12408E 00	-0.14287E 00	0.16296E00
0.20000E01	-0.17845E-01	-0.10978E 00	-0.12762E 00	0.17820E00
0.40000E01	-0.78005E-02	-0.90197E-03	-0.87024E-02	0.29712E00
0.60000E01	0.32762E-02	0.14991E 00	0.15318E 00	9.45901E00
0.80000E01	0.12331E-01	0.24631E 00	0.25864E 00	0.56446E00
0.10000E02	0.17523E-01	0.23966E 00	0.15718E 00	0.56301E00
0.12000E02	0.18160E-01	0.12819E 00	0.14635E 00	0.45218E00
0.14000E02	0.13632E-01	-0.30698E-01	-0.17065E-01	0.28876E00
0.16000E02	0.50069E-02	-0.10917E 00	-0.10417E 00	0.20166E00
0.18000E02	-0.27488E-02	-0.12935E 00	-0.13209E 00	0.17373E00
0.20000E02	-0.88685E-02	-0.13198E 00	-0.14084E 00	0.16498E00
0.22000E02	-0.13784E-01	-0.12867E 00	-0.14245E 00	0.16337E00

AVERAGE AND MAX. FLUX = 0.30582E 00 0.56446E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.34271E 01	0.53786E 02	0.33512E 01	0.18690E 03	0.28534E 00	0.64605E-01

B5-3-7 S(BR---CO)

0.0	-0.23068E-01	-0.14934E 00	-0.17241E 00	0.19658E00
0.20000E01	-0.21240E-01	-0.12791E 00	-0.14915E 00	0.21984E00
0.40000E01	-0.85695E-02	0.10376E-01	0.18063E-02	0.37080E00
0.60000E01	0.48973E-02	0.19323E 00	0.19812E 00	0.56711E00
0.80000E01	0.15668E-01	0.30372E 00	0.31338E 00	0.68837E00
0.10000E02	0.21610E-01	0.28694E 00	0.30855E 00	0.67754E00
0.12000E02	0.21966E-01	0.14504E 00	0.16701E 00	0.53599E00
0.14000E02	0.16054E-01	-0.47951E-01	-0.31897E-01	0.33709E00
0.16000E02	0.53670E-02	-0.13772E 00	-0.13235E 00	0.23663E00
0.18000E02	-0.40091E-02	-0.15920E 00	-0.16321E 00	0.20578E00
0.20000E02	-0.11354E-01	-0.16136E 00	-0.17272E 00	0.19627E00
0.22000E02	-0.17203E-01	-0.15648E 00	-0.17368E 00	0.19531E00

AVERAGE AND MAX. FLUX = 0.36899E 00 0.68837E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.34704E 01	0.54467E 02	0.33512E 01	0.18690E 03	0.27825E 00	0.63000E-01

B5-3-8 S(BR---CO)

00.	-0.21447E-01	-0.13985E 00	-0.16130E 00	0.18392E00
0.20000E01	-0.19972E-01	-0.12119E 00	-0.14116E 00	0.20406E00
0.40000E01	-0.83065E-02	0.58097E-02	-0.24968E-02	0.34272E00
0.60000E01	0.42608E-02	0.17657E 00	0.18083E 00	0.52605E00
0.80000E01	0.14392E-01	0.28194E 00	0.29634E 00	0.64156E00
0.10000E02	0.20062E-01	0.26924E 00	0.28931E 00	0.63453E00
0.12000E02	0.20535E-01	0.13902E 00	0.15955E 00	0.50477E00
0.14000E02	0.15157E-01	-0.41111E-01	-0.25954E-01	0.31927E00
0.16000E02	0.52524E-02	-0.12684E 00	-0.12159E 00	0.22363E00
0.18000E02	-0.35167E-02	-0.14793E 00	-0.15145E 00	0.19377E00
0.20000E02	-0.10403E-01	-0.15029E 00	-0.16069E 00	0.18453E00
0.22000E02	-0.15904E-01	-0.14601E 00	-0.16191E 00	0.18331E00

AVERAGE AND MAX. FLUX = 0.34522E 00 0.64156E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.33403E 01	0.52424E 02	0.33512E 01	0.18690E 03		
0.30035E 00	0.6805E-01					

B5-3-5 S(BR---CO)

0.0	-0.27137E-01	-0.17273E 00	-0.19987E 00	0.22804E00
0.20000E01	-0.24312E-01	-0.14391E 00	-0.16822E 00	0.25969E00
0.40000E01	-0.90694E-02	0.23590E-01	0.14520E-01	0.44243E00
0.60000E01	0.66196E-02	0.23639E 00	0.24301E 00	0.67092E00
0.80000E01	0.18936E-01	0.35844E 00	0.37737E 00	0.80528E00
0.10000E02	0.25494E-01	0.33011E 00	0.35560E 00	0.78351E00
0.12000E02	0.25496E-01	0.15817E 00	0.18366E 00	0.61157E00
0.14000E02	0.18197E-01	-0.66735E-01	-0.48539E-01	0.37937E00
0.16000E02	0.55346E-02	-0.16537E 00	-0.15984E 00	0.26807E00
0.18000E02	-0.53309E-02	-0.18735E 00	-0.19268E 00	0.23522E00
0.20000E02	-0.13795E-01	-0.18894E 00	-0.20273E 00	0.22518E00
0.22000E02	-0.20492E-01	-0.18246E 00	-0.20296E 00	0.22495E00

AVERAGE AND MAX. FLUX = 0.42791E 00 0.80528E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.33837E 01	0.53105E 02	0.33512E 01	0.18690E 03		
0.29270E 00	0.66272E-01					

B5-3-6 S(BR---CO)

0.0	-0.24944E-01	-0.16020E 00	-0.18515E 00	0.21112E00
0.20000E01	-0.22676E-01	-0.13545E 00	-0.15813E 00	0.23814E00
0.40000E01	-0.88289E-02	0.16142E-01	0.73132E-02	0.40358E00
0.60000E01	0.56689E-02	0.21288E 00	0.21855E 00	0.61482E00
0.80000E01	0.17163E-01	0.32893E 00	0.34610E 00	0.74237E00
0.10000E02	0.23400E-01	0.30707E 00	0.33047E 00	0.72674E00
0.12000E02	0.23604E-01	0.15145E 00	0.17505E 00	0.57132E00
0.14000E02	0.17061E-01	-0.56327E-01	-0.39266E-01	0.35700E00
0.16000E02	0.54657E-02	-0.15041E 00	-0.14495E 00	0.25132E00
0.18000E02	-0.46029E-02	-0.17220E 00	-0.17680E 00	0.21947E00
0.20000E02	-0.12468E-01	-0.17410E 00	-0.18657E 00	0.20970E00
0.22000E02	-0.18713E-01	-0.16850E 00	-0.18721E 00	0.20906E00

AVERAGE AND MAX. FLUX = 0.36927E 00 0.74237E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.32535E 01	0.51063E 02	0.33512E 01	0.18690E 03	0.31659E 00	0.71680E-01

B5-3-3 S(BR---CO)

0.0	-0.32854E-01	-0.20453E 00	-0.23739E 00	0.27183E00
0.20000E01	-0.28324E-01	-0.16371E 00	-0.19203E 00	0.31718E00
0.40000E01	-0.93655E-02	0.46983E-01	0.37617E-01	0.54684E00
0.60000E01	0.93404E-02	0.30037E 00	0.30971E 00	0.81893E00
0.80000E01	0.23686E-01	0.43511E 00	0.45880E 00	0.96801E00
0.10000E02	0.30951E-01	0.38729E 00	0.41824E 00	0.92746E00
0.12000E02	0.30308E-01	0.17161E 00	0.20192E 00	0.71113E00
0.14000E02	0.20936E-01	-0.96722E-01	-0.75786E-01	0.43343E00
0.16000E02	0.54802E-02	-0.20469E 00	-0.19921E 00	0.31000E00
0.18000E02	-0.73979E-02	-0.22669E 00	-0.23408E 00	0.27513E00
0.20000E02	-0.17378E-01	-0.22750E 00	-0.24487E 00	0.26434E00
0.22000E02	-0.25203E-01	-0.21855E 00	-0.24375E 00	0.26547E00

AVERAGE AND MAX. FLUX = 0.50922E 00 0.96801E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.32969E 01	0.51743E 02	0.33512E 01	0.18690E 03	0.30831E 00	0.69806E-01

B5-3-4 S(BR---CO)

0.0	-0.29734E-01	-0.18733E 00	-0.21707E 00	0.24797E00
0.20000E01	-0.26183E-01	-0.15334E 00	-0.17952E 00	0.28552E00
0.40000E01	-0.92642E-02	0.33466E-01	0.24202E-01	0.48924E00
0.60000E01	0.78124E-02	0.26498E 00	0.27279E 00	0.73783E00
0.80000E01	0.21072E-01	0.39334E 00	0.41441E 00	0.87945E00
0.10000E02	0.27974E-01	0.35663E 00	0.38461E 00	0.84964E00
0.12000E02	0.27704E-01	0.16501E 00	0.19272E 00	0.65775E00
0.14000E02	0.19481E-01	-0.79873E-01	-0.60392E-01	0.40464E00
0.16000E02	0.55514E-02	-0.18320E 00	-0.17765E 00	0.28738E00
0.18000E02	-0.62397E-02	-0.20524E 00	-0.21148E 00	0.25355E00
0.20000E02	-0.15399E-01	-0.20645E 00	-0.22185E 00	0.24319E00
0.22000E02	-0.22617E-01	-0.19889E 00	-0.22151E 00	0.24352E00

AVERAGE AND MAX. FLUX = 0.46504E 00 0.87945E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.31668E 01	0.49701E 02	0.33512E 01	0.18690E 03	0.33417E 00	0.75662E-01

B5-3-1 S(BR---CO)

0.0	-0.41401E-01	-0.24999E 00	-0.29139E 00	0.33729E00
0.20000E01	-0.33473E-01	-0.18512E 00	-0.21860E 00	0.41008E00
0.40000E01	-0.88786E-02	0.94897E-01	0.86019E-01	0.71470E00
0.60000E01	0.14037E-01	0.40309E 00	0.41713E 00	0.10458E01
0.80000E01	0.31101E-01	0.54735E 00	0.57845E 00	0.12071E01
0.10000E02	0.39088E-01	0.46316E 00	0.50225E 00	0.11309E01
0.12000E02	0.37161E-01	0.18018E 00	0.21734E 00	0.84602E00
0.14000E02	0.24419E-01	-0.14732E 00	-0.12290E 00	0.50577E00
0.16000E02	0.48083E-02	-0.26279E 00	-0.25798E 00	0.37070E00
0.18000E02	-0.10931E-01	-0.28555E 00	-0.29648E 00	0.33219E00
0.20000E02	-0.23140E-01	-0.28631E 00	-0.30945E 00	0.31923E00
0.22000E02	-0.32553E-01	-0.27296E 00	-0.30552E 00	0.32316E00

AVERAGE AND MAX. FLUX = 0.62868E 00 0.12071E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.32102E 01	0.50382E 02	0.33512E 01	0.18690E 03	0.32520E 00	0.73630E-01

B5-3-2 S(BR---CO)

0.0	-0.36663E-01	-0.22506E 00	-0.26173E 00	0.30095E00
0.20000E01	-0.30761E-01	-0.17470E 00	-0.20546E 00	0.35721E00
0.40000E01	-0.92885E-02	0.66201E-01	0.56913E-01	0.61959E00
0.60000E01	0.11343E-01	0.34513E 00	0.35648E 00	0.91915E00
0.80000E01	0.26946E-01	0.48566E 00	0.51261E 00	0.10753E01
0.10000E02	0.34581E-01	0.42272E 00	0.45730E 00	0.10200E01
0.12000E02	0.33414E-01	0.17718E 00	0.21060E 00	0.77327E00
0.14000E02	0.22580E-01	-0.11864E 00	-0.96059E-01	0.46662E00
0.16000E02	0.52630E-02	-0.23084E 00	-0.22558E 00	0.33710E00
0.18000E02	-0.89088E-02	-0.25286E 00	-0.26176E 00	0.30091E00
0.20000E02	-0.19879E-01	-0.25338E 00	-0.27326E 00	0.28941E00
0.22000E02	-0.28422E-01	-0.24259E 00	-0.27101E 00	0.29166E00

AVERAGE AND MAX. FLUX = 0.56268E 00 0.10753E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.24727E 01	0.38807E 02	0.33512E 01	0.18690E 03	0.54811E 00	0.12410E 00

B5-2-9 S(BR---CO)

0.0	-0.23909E-01	-0.14750E 00	-0.17141E 00	0.18600E00
0.20000E01	-0.17758E-01	-0.91093E-01	-0.10885E 00	0.24855E00
0.40000E01	-0.38682E-02	0.77469E-01	0.73600E-01	0.43100E00
0.60000E01	0.87924E-02	0.24257E 00	0.25136E 00	0.60876E00
0.80000E01	0.18101E-01	0.30770E 00	0.32580E 00	0.68320E00
0.10000E02	0.22278E-01	0.24607E 00	0.26835E 00	0.62575E00
0.12000E02	0.20751E-01	0.83325E-01	0.10408E 00	0.46148E00
0.14000E02	0.13150E-01	-0.85064E-01	-0.71914E-01	0.28549E00
0.16000E02	0.23337E-02	-0.14277E 00	-0.14044E 00	0.21696E00
0.18000E02	-0.65269E-02	-0.16048E 00	-0.16700E 00	0.19040E00
0.20000E02	-0.13774E-01	-0.16733E 00	-0.18110E 00	0.17630E00
0.22000E02	-0.19490E-01	-0.16335E 00	-0.18284E 00	0.17457E00

AVERAGE AND MAX. FLUX = 0.35740E 00 0.68320E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.25161E 01	0.39488E 02	0.33512E 01	0.18690E 03	0.52937E 00	0.11986E 00

B5-2-10 S(BR---CO)

0.0	-0.22327E-01	-0.13743E 00	-0.15976E 00	0.17530E00
0.20000E 01	-0.16833E-01	-0.87128E-01	-0.10396E 00	0.23110E00
0.40000E 01	-0.38450E-02	0.68861E-01	0.65016E-01	0.40008E00
0.60000E 01	0.80738E-02	0.22467E 00	0.23275E 00	0.56781E00
0.80000E 01	0.16868E-01	0.28831E 00	0.30518E 00	0.64024E00
0.10000E 02	0.20857E-01	0.23308E 00	0.25394E 00	0.58900E00
0.12000E 02	0.19509E-01	0.81548E-01	0.10106E 00	0.43612E00
0.14000E 02	0.12463E-01	-0.78491E-01	-0.66028E-01	0.26903E00
0.16000E 02	-0.22932E-02	-0.13442E 00	-0.13213E 00	0.20293E00
0.18000E 02	-0.60445E-02	-0.15081E 00	-0.15685E 00	0.17821E00
0.20000E 02	-0.12812E-01	-0.15648E 00	-0.16929E 00	0.16577E00
0.22000E 02	-0.18123E-01	-0.15217E 00	-0.17029E 00	0.16477E00

AVERAGE AND MAX. FLUX = 0.33506E 00 0.64024E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.23859E 01	0.37446E 02	0.33512E 01	0.18690E 03		
0.58869E 00	0.13329E 00					

B5-2-7 S(BR---CO)

0.0	-0.27821E-01	-0.17233E 00	-0.20015E 00	0.21225E00
0.20000E01	-0.19996E-01	-0.10058E 00	-0.12058E 00	0.29182E00
0.40000E01	-0.38781E-02	0.99339E-01	0.95461E-01	0.50787E00
0.60000E01	0.10599E-01	0.28715E 00	0.29774E 00	0.71015E00
0.80000E01	0.21160E-01	0.35551E 00	0.37667E 00	0.78908E00
0.10000E02	0.25783E-01	0.27765E 00	0.30343E 00	0.71584E00
0.12000E02	0.23794E-01	0.87013E-01	0.11081E 00	0.52321E00
0.14000E02	0.14809E-01	-0.10167E 00	-0.86865E-01	0.32554E00
0.16000E02	0.24026E-02	-0.16333E 00	-0.16093E 00	0.25148E00
0.18000E02	-0.77355E-02	-0.18424E 00	-0.19198E 00	0.22043E00
0.20000E02	-0.16163E-01	-0.19403E 00	-0.21019E 00	0.20222E00
0.22000E02	-0.22878E-01	-0.19089E 00	-0.21377E 00	0.19864E00

AVERAGE AND MAX. FLUX = 0.41241E 00 0.78908E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.24293E 01	0.38127E 02	0.33512E 01	0.18690E 03		
0.56786E 00	0.128571E 00					

B5-2-8 S(BR---C)

0.0	-0.25723E-01	-0.15902E 00	-0.18474E 00	0.19820E00
0.20000E01	-0.18805E-01	-0.95563E-01	-0.11437E 00	0.26857E00
0.40000E01	-0.38816E-02	0.87489E-01	0.83607E-01	0.46655E00
0.60000E01	0.96241E-02	0.26317E 00	0.27279E 00	0.65573E00
0.80000E01	0.19517E-01	0.32989E 00	0.34941E 00	0.73235E00
0.10000E02	0.23904E-01	0.26081E 00	0.28471E 00	0.66765E00
0.12000E02	0.22166E-01	0.85163E-01	0.10733E 00	0.49027E00
0.14000E02	0.13926E-01	-0.92708E-01	-0.78782E-01	0.30416E00
0.16000E02	0.23712E-02	-0.15232E 00	-0.14995E 00	0.23299E00
0.18000E02	-0.70841E-02	-0.17151E 00	-0.17859E 00	0.20435E00
0.20000E02	-0.14879E-01	-0.17972E 00	-0.19459E 00	0.18835E00
0.22000E02	-0.21058E-01	-0.17612E 00	-0.19718E 00	0.18576E00

AVERAGE AND MAX. FLUX = 0.38294E 00 0.73235E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22992E 01	0.36084E 02	0.33512E 01	0.18690E 03	0.63396E 00	0.14354E 00

B5-2-5 S(BR---CO)

0.0	-0.33188E-01	-0.20634E 00	-0.23953E 00	0.24788E 00
0.20000E01	-0.22930E-01	-0.11239E 00	-0.13532E 00	0.35219E 00
0.40000E01	-0.37668E-02	0.13122E 00	0.12746E 00	0.61487E 00
0.60000E01	0.13154E-01	0.34922E 00	0.36237E 00	0.84979E 00
0.80000E01	0.25387E-01	0.42061E 00	0.44599E 00	0.93341E 00
0.10000E02	0.30574E-01	0.31937E 00	0.34994E 00	0.83736E 00
0.12000E02	0.27908E-01	0.90249E-01	0.11816E 00	0.60557E 00
0.14000E02	0.16990E-01	-0.12502E 00	-0.10803E 00	0.37939E 00
0.16000E02	0.24271E-02	-0.19115E 00	-0.18872E 00	0.29869E 00
0.18000E02	-0.94364E-02	-0.21664E 00	-0.22607E 00	0.26134E 00
0.20000E02	-0.19482E-01	-0.23070E 00	-0.25018E 00	0.23724E 00
0.22000E02	-0.27569E-01	-0.22881E 00	-0.25638E 00	0.23104E 00

AVERAGE AND MAX. FLUX = 0.48742E 00 0.93341E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.23425E 01	0.36765E 02	0.33512E 01	0.18690E 03	0.61070E 00	0.13827E 00

B5-2-6 S(BR---CO)

0.0	-0.30277E-01	-0.18789E 00	-0.21817E 00	0.22861E 00
0.20000E01	-0.21360E-01	-0.10619E 00	-0.12755E 00	0.31923E 00
0.40000E01	-0.38461E-02	0.11362E 00	0.10977E 00	0.55656E 00
0.60000E01	0.11756E-01	0.31540E 00	0.32716E 00	0.77394E 00
0.80000E01	0.23089E-01	0.38538E 00	0.40847E 00	0.85526E 00
0.10000E02	0.27977E-01	0.29700E 00	0.32497E 00	0.77176E 00
0.12000E02	0.25685E-01	0.88773E-01	0.11446E 00	0.56124E 00
0.14000E02	0.15821E-01	-0.11229E 00	-0.94974E-01	0.35031E 00
0.16000E02	0.24235E-02	-0.17613E 00	-0.17371E 00	0.27308E 00
0.18000E02	-0.85075E-02	-0.19909E 00	-0.20760E 00	0.23919E 00
0.20000E02	-0.17674E-01	-0.21078E 00	-0.22846E 00	0.21833E 00
0.22000E02	-0.25016E-01	-0.20820E 00	-0.23322E 00	0.21357E 00

AVERAGE AND MAX. FLUX = 0.44678E 00 0.85526E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22124E 01	0.34723E 02	0.33512E 01	0.18690E 03	0.68466E 00	0.15502E 00

B5-2-3 S(BR---CO)

0.0	-0.41009E-01	-0.25617E 00	-0.29718E 00	0.29860E00
0.20000E01	-0.26840E-01	-0.12602E 00	-0.15286E 00	0.44292E00
0.40000E01	-0.33131E-02	0.18276E 00	0.17945E 00	0.77522E00
0.60000E01	0.17044E-01	0.44180E 00	0.45884E 00	0.10546E01
0.80000E01	0.31599E-01	0.51371E 00	0.54531E 00	0.11411E01
0.10000E02	0.37508E-01	0.37567E 00	0.41318E 00	0.10090E01
0.12000E02	0.33753E-01	0.90457E-01	0.12421E 00	0.71999E00
0.14000E02	0.19947E-01	-0.15942E 00	-0.13947E 00	0.45631E00
0.16000E02	0.23346E-02	-0.23011E 00	-0.22777E 00	0.36800E00
0.18000E02	-0.11993E-01	-0.26329E 00	-0.27528E 00	0.32050E00
0.20000E02	-0.24430E-01	-0.18465E 00	-0.30908E 00	0.28670E00
0.22000E02	-0.34553E-01	-0.28501E 00	-0.31956E 00	0.27622E00

AVERAGE AND MAX. FLUX = 0.59578E 00 0.11411E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22558E 01	0.35403E 02	0.33512E 01	0.18690E 03	0.65858E 00	0.14911E 00

B5-2-4 S(BR---CO)

0.0	-0.36697E-01	-0.22863E 00	-0.26532E 00	0.27086E00
0.20000E01	-0.24743E-01	-0.11909E 00	-0.14394E 00	0.39234E00
0.40000E01	-0.36079E-02	0.15353E 00	0.14992E 00	0.68610E00
0.60000E01	0.14874E-01	0.39042E 00	0.40530E 00	0.94148E00
0.80000E01	0.28167E-01	0.46269E 00	0.49085E 00	0.10270E01
0.10000E02	0.33694E-01	0.34537E 00	0.37906E 00	0.91524E00
0.12000E02	0.30554E-01	0.91059E-01	0.12161E 00	0.65779E00
0.14000E02	0.18350E-01	-0.14045E 00	-0.12210E 00	0.41408E00
0.16000E02	0.24028E-02	-0.20892E 00	-0.20652E 00	0.32966E00
0.18000E02	-0.10574E-01	-0.23767E 00	-0.24825E 00	0.28793E00
0.20000E02	-0.21685E-01	-0.25481E 00	-0.27649E 00	0.25969E00
0.22000E02	-0.30677E-01	-0.25384E 00	-0.28451E 00	0.25166E00

AVERAGE AND MAX. FLUX = 0.53618E 00 0.10270E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.21256E 01	0.33361E 02	0.33512E 01	0.18690E 03		
0.74169E 00	0.16793E 00					

B5-2-1 S(BR---CO)

0.0	-0.53524E-01	-0.33870E 00	-0.39223E 00	0.37387E00
0.20000E01	-0.31945E-01	-0.13632E 00	-0.16826E 00	0.59784E00
0.40000E01	-0.17949E-02	0.28093E 00	0.27913E 00	0.10452E01
0.60000E01	0.23656E-01	0.59570E 00	0.61926E 00	0.13855E01
0.80000E01	0.41575E-01	0.65592E 00	0.69749E 00	0.14636E01
0.10000E02	0.48372E-01	0.45049E 00	0.49886E 00	0.12650E01
0.12000E02	0.42612E-01	0.76789E-01	0.11940E 00	0.88550E00
0.14000E02	0.24037E-01	-0.21252E 00	-0.18849E 00	0.57761E00
0.16000E02	0.19695E-02	-0.28515E 00	-0.28318E 00	0.48292E00
0.18000E02	-0.16158E-01	-0.33488E 00	-0.35104E 00	0.41506E00
0.20000E02	-0.32605E-01	-0.37266E 00	-0.40527E 00	0.36083E00
0.22000E02	-0.46229E-01	-0.37940E 00	-0.42563E 00	0.34047E00

AVERAGE AND MAX. FLUX = 0.76610E 00 0.14636E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.21690E 01	0.34042E 02	0.33512E 01	0.18590E 03		
0.71232E 00	0.16128E 00					

B5-2-2 S(BR---CO)

0.0	-0.46443E-01	-0.29138E 00	-0.33782E 00	0.33246E00
0.20000E01	-0.29250E-01	-0.13241E 00	-0.16166E 00	0.50862E00
0.40000E01	-0.27782E-02	0.22279E 00	0.22001E 00	0.89029000
0.60000E01	0.19860E-01	0.50772E 00	0.52758E 00	0.11979E01
0.80000E01	0.35935E-01	0.57668E 00	0.61261E 00	0.12829E01
0.10000E02	0.42271E-01	0.41081E 00	0.45308E 00	0.11234E01
0.12000E02	0.37686E-01	0.86887E-01	0.12457E 00	0.79486E00
0.14000E02	0.21929E-01	-0.18301E 00	-0 16118E 00	0.50911E00
0.16000E02	0.21993E-02	-0.25541E 00	-0.25321E 00	0.41707E00
0.18000E02	-0.13803E-01	-0.25952E 00	-0.30883E 00	0.36146E00
0.20000E02	-0.27946E-01	-0.32622E 00	-0.35056E 00	0.31972E00
0.22000E02	-0.39538E-01	-0.32515E 00	-0.36469E 00	0.30559E00

AVERAGE AND MAX. FLUX = 0.67028E 00 0.12829E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.14316E 01	0.22467E 02	0.33512E 01	0.8690E 03		
0.16353E 01	0.37025E 00					

B5-1-9 S(BR---CO)

0.0	-0.29475E-01	-0.20351E 00	-0.23299E 00	0.16500E00
0.20000E01	-0.13913E-01	-0.54096E-01	-0.68009E-01	0.32998E00
0.40000E01	0.16057E-02	0.19618E 00	0.19779E 00	0.59577E00
0.60000E01	0.13970E-01	0.34695E 00	0.36092E 00	0.75890E00
0.80000E01	0.22300E-01	0.34168E 00	0.36398E 00	0.76196E00
0.10000E02	0.25013E-01	0.19546E 00	0.22047E 00	0.61846E00
0.12000E02	0.21061E-01	-0.14842E-01	0.62188E-02	0.40421E00
0.14000E02	0.10524E-01	-0.11917E 00	-0.10865E 00	0.28934E00
0.16000E02	0.35814E-03	-0.12640E 00	-0.12604E 00	0.27195E00
0.18000E02	-0.82470E-02	-0.15554E 00	-0.16378E 00	0.23420E00
0.20000E02	-0.17377E-01	-0.19129E 00	-0.20867E 00	0.18931E00
0.22000E02	-0.26044E-01	-0.21413E 00	-0.24017E 00	0.15782E00

AVERAGE AND MAX. FLUX = 0.39799E 00 0.76196E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.1000E 01	0.14749E 01	0.23148E 02	0.33512E 01	0.18690E 03		
0.15405E 01	0.34879E 00					

B5-1-10 S(BR---CO)

0.0	-0.27230E-01	-0.18630E 00	-0.21353E 00	0.15695E00
0.20000E01	-0.13125E-01	-0.50101E-01	-0.63226E-01	0.30725E00
0.40000E01	0.12896E-02	0.17910E 00	0.18039E 00	0.55087E00
0.60000E01	0.12858E-01	0.31920E 0	0.33206E 00	0.70254E00
0.80000E01	0.20696E-01	0.31679E 00	0.33748E 00	0.70796E00
0.10000E02	0.23294E-01	0.18450E 00	0.20779E 00	0.57827E00
0.12000E02	0.19700E-01	-0.85685E-02	0.11131E-01	0.38161E00
0.14000E02	0.99836E-02	-0.10902E 00	-0.99038E-01	0.27144E00
0.16000E02	0.40118E-03	-0.11935E 00	-0.11894E 00	0.25153E00
0.18000E02	-0.77291E-02	-0.14723E 00	-0.15496E 00	0.21551E00
0.20000E02	-0.16213E-01	-0.17946E 00	-0.19568E 00	0.17480E00
0.22000E02.0	-24114E-01	-0.19849E 00	-0.22260E 00	0.14787E00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13448E 01	0.21106E 02	0.33512E 01	0.18690E 03	0.18531E 01	0.41956E 00

B5-1-7 S(BR---CO)

0.0	-0.25140E-01	-0.24678E 00	-0.28192E 00	0.18548E00
0.20000E01	-0.15906E-01	-0.64324E-01	-0.80230E-01	0.38717E00
0.40000E01	0.24016E-02	0.23903E 00	0.24144E 00	0.70884E00
0.60000E01	0.16780E-01	0.41686E 00	0.43364E 00	0.90105E00
0.80000E01	0.26353E-01	0.40461E 00	0.43097E 00	0.89837E00
0.10000E02	0.29353E-01	0.22334E 00	0.25270E 00	0.72010E00
0.12000E02	0.24498E-01	-0.30600E-01	-0.61026E-02	0.46130E00
0.14000E02	0.11882E-01	-0.14500E 00	-0.13312E 00	0.33428E00
0.16000E02	0.23780E-03	-0.14445E 00	-0.14421E 00	0.32319E00
0.18000E02	-0.95622E-02	-0.17657E 00	-0.18613E 00	0.28127E00
0.20000E02	-0.20313E-01	-0.22100E 00	-0.24132E 00	0.22609E00
0.22000E02	-0.30900E-01	-0.25331E 00	-0.28421E 00	0.18319E00

AVERAGE AND MAX. FLUX = 0.46740E 00 0.90105E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13882E 01	0.21787E 02	0.33512E 01	0.18690E 03	0.17391E 01	0.39375E 00

B5-1-8 S(BR---CO)

0.0	-0.32080E-01	-0.22342E 00	-0.25550E 00	0.17441E00
0.20000E01	-0.14830E-01	-0.58796E-01	-0.73626E-01	0.35628E00
0.40000E01	0.19708E-02	0.21589E 00	0.21786E 00	0.64777E00
0.60000E01	0.15261E-01	0.37910E 00	0.39436E 00	0.82427E00
0.80000E01	0.24163E-01	0.37061E 00	0.39477E 00	0.82468E00
0.10000E02	0.27008E-01	0.20827E 00	0.23528E 00	0.66519E00
0.12000E02	0.22642E-01	-0.22077E-01	0.56511E-03	0.43048E00
0.14000E02	0.11150E-01	-0.13103E 00	-0.11988E 00	0.31003E00
0.16000E02	0.30444E-03	-0.13468E 00	-0.13438E 00	0.29553E00
0.18000E02	-0.87509E-02	-0.16521E 00	-0.17406E 00	0.25585E00
0.20000E02	-0.18728E-01	-0.20497E 00	-0.22370E 00	0.20621E00
0.22000E02	-0.28278E-01	-0.23217E 00	-0.26045E 00	0.16946E00

AVERAGE AND MAX. FLUX = 0.42991E 00 0.82468E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.12580E 01	0.19744E 02	0.33512E 01	0.18690E 03		
0.21175E 01	0.47943E 00					

B5-1-5 S(BR---CO)

0.0	-0.43228E-01	-0.30878E 00	-0.35201E 00	0.21414E00
0.20000E01	-0.18701E-01	-0.78717E-01	-0.97418E-01	0.46873E00
0.40000E01	0.35730E-02	0.300650 00	0.30423E 00	0.87037E00
0.60000E01	0.20805E-01	0.51690E 00	0.53770E 00	0.11038E01
0.80000E01	32130E-01	0.49426E 00	0.52639E 00	0.10925E01
0.10000E02	0.35526E-01	0.26251E 00	0.29804E 00	0.86418E00
0.12000E02	0.29368E-01	-0.53927E-01	-0.24559E-01	0.54159E00
0.14000E02	0.13777E-01	-0.18200E 00	-0.16822E 00	0.39792E00
0.16000E02	0.50932E-04	-0.16990E 00	-0.16985E 00	0.39630E00
0.18000E02	-0.11430E-01	-0.20618E 00	-0.21761E 00	0.34854E00
0.20000E02	-0.24489E-01	-0.26308E 00	-0.28757E 00	0.27858E00
0.22000E02	-0.37833E-01	-0.30916E 00	-0.34699E 00	0.21916E00

AVERAGE AND MAX. FLUX = 0.56615E 00 0.11038E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13014E-01	0.20425E 02	0.33512E 01	0.18690E 03		
0.19787E 01	0.44800E 00					

B5-1-6 S(BR---CO)

0.0	-0.38790E-01	-0.27470E 00	-0.31349E 00	0.19857E00
0.20000E01	-0.17179E-01	-0.70872E-01	-0.88052E-01	0.42401E00
0.40000E01	0.29229E-02	0.26673E 00	0.26966E 00	0.78171E00
0.60000E01	0.18595E-01	0.46196E 00	0.48056E 00	0.99262E00
0.80000E01	0.28964E-01	0.44514E 00	0.47410E 00	0.98616E00
0.10000E02	0.32145E-01	0.241009E 00	0.2733E 00	0.78539E00
0.12000E02	0.26704E-01	-0.40942E-01	-0.14237E-01	0.49782E00
0.14000E02	0.12746E-01	-0.16170E 00	-0.14896E 00	0.36310E00
0.16000E02	0.15508E-03	-0.15604E 00	-0.15589E 00	0.35617E00
0.18000E02	-0.10409E-01	-0.19005E 00	-0.20046E 00	0.31160E00
0.20000E02	-0.22202E-01	-0.24006E 00	-0.26226E 00	0.24980E00
0.22000E02	-0.34028E-01	-0.27851E 00	-0.31254E 00	0.19952E00

AVERAGE AND MAX. FLUX = 0.51206E 00 0.99262E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.11713E 01	0.18382E 02	0.33512E 01	0.18690E 03	0.24428E 01	0.55309E 00

B5-1-3 S(BR---CO)

0.0	-0.55828E-01	-0.40703E 00	-0.46286E 00	0.25494E00
0.20000E01	-0.22813E-01	-0.10043E 00	-0.12324E 00	0.59455E00
0.40000E01	0.55536E-02	0.39889E 00	0.40444E 00	0.11222E01
0.60000E01	0.27103E-01	0.67379E 00	0.70090E 00	0.14187E01
0.80000E01	0.41041E-01	0.63254E 00	0.67358E 00	0.13914E01
0.10000E02	0.44986E-01	0.31980E 00	0.36479E 00	0.10826E01
0.12000E02	0.36759E-01	-0.94501E-01	-0.577423-01	0.66005E00
0.14000E02	0.16526E-01	-0.23973E 00	-0.22320E 00	0.49459E00
0.16000E02	-0.26674E-03	-0.20694E 00	-0.20720E 00	0.51059E00
0.18000E02	-0.14237E-01	-0.24943E 00	-0.26366E 00	0.45413E00
0.20000E02	-0.30990E-01	-0.32685E 00	-0.35773E 00	0.36006E00
0.22000E02	-0.48628E-01	-0.39621E 00	-0.44484E 00	0.27295E00

AVERAGE AND MAX. FLUX = 0.71779E 00 0.14187E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.12147E 01	0.19063E 02	0.33512E 01	0.18690E 03	0.22714E 01	0.51429E 00

B5-1-4 S(BR---CO)

0.0	-0.48750E-01	-0.35153E 00	-0.40028E 00	0.23274E00
0.20000E01	-0.20545E-01	-0.88307E-01	-0.10885E 00	0.52416E00
0.40000E01	0.44142E-02	0.34334E 00	0.34775E 00	0.98077E00
0.60000E01	0.23561E-01	0.58547E 00	0.60903E 00	0.12420E01
0.80000E01	0.36053E-01	0.55509E 00	0.59115E 00	0.12242E01
0.10000E02	0.39701E-01	0.28827E 00	0.32797E 00	0.96098E00
0.12000E02	0.32643E-01	-0.70952E-01	-0.38309E-01	0.59471E00
0.14000E02	0.15018E-01	-0.20726E 00	-0.19224E 00	0.44077E00
0.16000E02	-0.83845E-04	-0.18660E 00	-0.18669E 00	0.44633E00
0.18000E02	-0.12691E-01	-0.22568E 00	-0.23836E 00	0.39466E00
0.20000E02	-0.27313E-01	-0.29138E 00	-0.31870E 00	0.31432E00
0.22000E02	-0.42568E-01	-0.34732E 00	-0.38989E 00	0.24313E00

AVERAGE AND MAX. FLUX = 0.63301E 00 0.12420E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.10845E 01	0.17021E 02	0.33512E 01	0.18690E 03	0.28493E 01	0.64512E 00

B5-1-1 S(BR---CO)

0.0	-0.78568E-01	-0.59188E	00-0.67044E00	0.30995E00
0.20000E01	-0.29339E-01	-0.14108E	00-0.17041E00	0.80998E00
0.40000E01	0.97233E-02	0.58225E	00 0.59197E00	0.15724E01
0.60000E01	0.38519E-01	0.96097E	00 0.99949E00	0.19799E01
0.80000E01	0.56654E-01	0.87784E	00 0.93449E00	0.19149E00
0.10000E02	0.61291E-01	0.40908E	00 0.47038E00	0.15508E01
0.12000E02	0.49190E-01	-0.18600E	00-0.13681E00	0.84358E00
0.14000E02	0.20588E-01	-0.34694E	00-0.32635E00	0.65405E00
0.16000E02	-0.98192E-03	-0.26296E	00-0.26395E00	0.71645E00
0.18000E02	-0.18744E-01	-0.31279E	00-0.33154E00	0.64886E00
0.20000E02	-0.41680E-01	-0.43082E	00-0.47250E00	0.50789E00
0.22000E02	-0.67826E-01	-0.55095E	00-0.61878E00	0.36162E00

AVERAGE AND MAX. FLUX = 0.98040E 00 0.19799E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
1000E 01	0.11279E 01	0.17702E 02	0.33512E 01	0.18690E 03	0.26343E 01	0.59645E 00

B5-1-2 S(BR---CO)

0.0	-0.65267E-01	-0.48249E	00-0.54776E00	0.28104E00
0.20000E01	-0.25661E-01	-0.11669E	00-0.14235E00	0.68664E00
0.40000E01	0.71888E-02	0.47427E	00 0.48146E00	0.13103E01
0.60000E01	0.31838E-01	0.79237E	00-0.82420E00	0.16530E01
0.80000E01	0.47606E-01	0.73493E	00 0.78253E00	0.16113E01
0.10000E02	0.51890E-01	0.35906E	00 0.41095E00	0.12397E01
0.12000E02	0.42077E-01	-0.12939E	00-0.87163E01	0.74148E00
0.14000E02	0.18368E-01	-0.28347E	00-0.26510E00	0.56369E00
0.16000E02	-0.53461E-03	-0.23194E	00-0.23247E00	0.59632E00
0.18000E02	-0.16208E-01	-0.27837E	00-0.29457E00	0.53422E00
0.20000E02	-0.35505E-01	-0.37218E	00-0.40768E00	0.42111E00
0.22000E02	-0.56666E-01	-0.46109E	00-0.51776E00	0.31103E00

AVERAGE AND MAX. FLUX = 0.82879E 00 0.16530E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45550E 01	0.71487E 02	0.33512E 01	0.18690E 03	0.16152E 00	0.36571E-01

B4-4-9 E(BR---CO)

0.0	-0.16255E-01	-0.89926E-01	-0.10618E 00	0.11925E00
0.20000E01	-0.17623E-01	-0.96565E-01	-0.11419E 00	0.11124E00
0.40000E01	-0.10525E-01	0.10729E 00	0.96763E-01	0.32219E00
0.60000E01	-0.79268E-03	0.22387E 00	0.22307E 00	0.44851E00
0.80000E01	0.82189E-02	0.17828E 00	0.18650E 00	0.41193E00
0.10000E02	0.14425E-01	0.47683E-01	0.62107E-01	0.28754E00
0.12000E02	0.16738E-01	-0.12883E-01	0.38545E-02	0.22929E00
0.14000E02	0.14345E-01	-0.43392E-01	-0.29037E-01	0.19640E00
0.16000E02	0.76098E-02	-0.67522E-01	-0.59913E-01	0.16552E00
0.18000E02	0.47242E-03	-0.80880E-01	-0.80408E-01	0.14502E00
0.20000E02	-0.56502E-02	-0.85537E-01	-0.91187E-01	0.13425E00
0.22000E02	-0.10906E-01	-0.87594E-01	-0.98500E-01	0.12693E00

AVERAGE AND MAX. FLUX = 0.22543E 00 0.44851E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45983E 01	0.72168E 02	0.33512E 01	0.18690E 03	0.15849E 00	0.35995E-01

B4-4-10 E(BR---CO)

0.0	-0.15232E-01	-0.85340E-01	-0.10057E 00	0.11303E00
0.20000E01	-0.16645E-01	-0.91643E-01	-0.10829E 00	0.10531E00
0.40000E01	-0.10117E-01	0.97419E-01	0.87302E-01	0.30090E00
0.60000E01	-0.10085E-02	0.20877E 00	0.20777E 00	0.42137E00
0.80000E01	0.75088E-02	0.16898E 00	0.17649E 00	0.39009E00
0.10000E02	0.13446E-01	0.47552E-01	0.60997E-01	0.27460E00
0.12000E02	0.15743E-01	-0.10165E-01	0.55784E-02	0.21918E00
0.14000E02	0.13616E-01	-0.39641E-01	-0.26025E-01	0.18757E00
0.16000E02	0.73693E-02	-0.62828E-01	-0.55459E-01	0.15814E00
0.18000E02	0.66001E-03	-0.75923E-01	-0.75263E-01	0.13834E00
0.20000E02	-0.51414E-02	-0.80735E-01	-0.85876E-01	0.12772E00
0.22000E02	-0.10146E-01	-0.82972E-01	-0.93118E-01	0.12048E00

AVERAGE AND MAX. FLUX = 0.21360E 00 0.42137E 00

LO	LI	KO	KI	ALFAO	ALFAI
0.4800	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	0.44682E 01	0.70126E 02	0.33512E 01	0.18690E 03	0.16786E 00	0.38006E-01

B4-4-7 E(BR---CO)

0.0	-0.18738E-01	-0.10078E 00	-0.11952E 00	0.13400E00
0.20000E01	-0.19948E-01	-0.10819E 00	-0.12814E 00	0.12538E00
0.40000E01	-0.11418E-01	0.13259E 00	0.12117E 00	0.37469E00
0.60000E01	-0.17265E-03	0.26090E 00	0.26073E 00	0.51424E00
0.80000E01	0.10006E-01	0.19995E 00	0.20996E 00	0.46347E00
0.10000E02	0.16819E-01	0.46757E-01	0.63575E-01	0.31709E00
0.12000E02	0.19122E-01	-0.20114E-01	-0.99107E-02	0.25252E00
0.14000E02	0.16047E-01	-0.52673E-01	-0.36626E-01	0.21689E00
0.16000E02	0.81059E-02	-0.78958E-01	-0.70852E-01	0.18266E00
0.18000E02	-0.55176E-04	-0.92790E-01	-0.92845E-01	0.16067E00
0.20000E02	-0.69296E-02	-0.96963E-01	-0.10389E 00	0.14962E00
0.22000E02	-0.12767E-01	-0.98545E-01	-0.11131E 00	0.14220E00

AVERAGE AND MAX. FLUX = 0.25352E 00 0.51424E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45116E 01	0.70807E 02	0.33512E 01	0.18690E 03	0.16465E 00	0.37278E-01

B4-4-8 E(BR---CO)

0.0	-0.17414E-01	-0.95042E-01	-0.11246E 00	0.12619E00
0.20000E01	-0.18717E-01	-0.10204E 00	-0.12076E 00	0.11789E00
0.40000E01	-0.10959E-01	0.11885E 00	0.10789E 00	0.34654E00
0.60000E01	-0.52037E-03	0.24108E 00	0.24056E 00	0.47921E00
0.80000E01	0.90418E-02	0.18857E 00	0.19761E 00	0.43626E00
0.10000E02	0.15540E-01	0.47474E-01	0.63014E-01	0.30166E00
0.12000E02	0.17856E-01	-0.16147E-01	0.17093E-02	0.24036E00
0.14000E02	0.15152E-01	-0.47683E-01	-0.32532E-01	0.20612E00
0.16000E02	-0.78571E-02	-0.72855E-01	-0.64998E-01	0.17365E00
0.18000E02	0.23894E-03	-0.86462E-01	-0.86223E-01	0.15243E00
0.20000E02	-0.62396E-02	-0.90911E-01	-0.97151E-01	0.14150E00
0.22000E02	-0.11771E-01	-0.92754E-01	-0.10453E 00	0.13412E00

AVERAGE AND MAX. FLUX = 0.23865E 00 0.47921E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1

0.10000E 01 0.43814E 01 0.68764E 02 0.33512E 01 0.18690E 03
0.17457E 00 0.39526E-01

B4-4-5 E(BR---CO)

0.0 -	0.22037E-01-	0.11459E 00-	0.13663E 00	0.15296E00
0.20000E01-	0.22928E-01-	0.12307E 00-	0.14600E 00	0.14359E00
0.40000E01-	0.12380E-01	0.16948E 00	0.15710E 00	0.44669E00
0.60000E01	0.86752E-03	0.31096E 00	0.31183E 00	0.60142E00
0.80000E01	0.12518E-01	0.22648E 00	0.23900E 00	0.52859E00
0.10000E02	0.20031E-01	0.42665E	0.62695E-01	0.35229E00
0.12000E02	0.22221E-01	-0.31047E-01	-0.88262E-02	0.28076E00
0.14000E02	0.18152E-01	-0.65410E-01	-0.47258E-01	0.24233E00
0.16000E02	0.85659E-02	-0.94221E-01	-0.85655E-01	0.20394E00
0.18000E02	-0.91606E-03	-0.10833E 00	-0.10925E 00	0.18034E00
0.20000E02	-0.87263E-02	-0.11164E 00	-0.12037E 00	0.16922E00
0.22000E02	-0.15278E-01	-0.11250E 00	-0.12778E 00	0.16181E00

AVERAGE AND MAX. FLUX = 0.28959E 00 0.60142E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1

0.10000E 01 0.44248E 01 0.69445E 02 0.33512E 01 0.18690E 03
0.17116E 00 0.38754E-01

B4-4-6 E(BR---CO)

0.0 -	0.20262E-01-	0.10725E 00-	0.12751E 00	0.14284E00
0.20000E01-	0.21342E-01-	0.11514E 00-	0.13648E 00	0.13387E00
0.40000E01-	0.11895E-01	0.14915E 00	0.13726E 00	0.40761E00
0.60000E01	0.27719E-03	0.28393E 00	0.28421E 00	0.55456E00
0.80000E01	0.11147E-01	0.21256E 00	0.22371E 00	0.4946E00
0.10000E02	0.18299E-01	0.45279E-01	0.63578E-01	0.3393E00
0.12000E02	0.20565E-01	-0.24988E-01	-0.44232E-02	0.2593E00
0.14000E02	0.17043E-01	-0.58512E-01	-0.41469E-01	0.2289E00
0.16000E02	0.83472E-02	-0.86004E-01	-0.77657E-01	0.1970E00
0.18000E02	-0.43048E-03	-0.10001E 00	-0.10045E 00	0.1691E00
0.20000E02	-0.77466E-02	-0.10382E 00	-0.11157E 00	0.1579E00
0.22000E02	-0.13923E-01	-0.10508E 00	-0.11900E 00	0.1535E00

AVERAGE AND MAX. FLUX = 0.27035E 00 0.55456E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.43380E 01	0.68083E 02	0.33512E 01	0.18690E 03	0.17808E 00	0.40320E-01

B4-4-4 E(BR---CO)

0.0	0.24124E-01-	0.12298E 00-	0.14710E 00	0.16467E00
0.20000E01-	0.24741E-01-	0.13220E 00-	0.15694E 00	0.15483E00
0.40000E01-	0.12849E-01	0.19493E 00	0.18208E 00	0.49386E00
0.60000E01	0.16545E-02	0.34303E 00	0.34469E 00	0.69646E00
0.80000E01	0.14187E-01	0.24173E 00	0.25592E 00	0.56769E00
0.10000E02	0.22078E-01	0.38347E-01	0.60424E-01	0.37220E00
0.12000E02	0.24135E-01-	0.38656E-01-	0.14521E-01	0.29725E00
0.14000E02	0.19387E-01-	0.73638E-01-	0.54251E-01	0.25752E00
0.16000E02	0.87365E-02-	0.10391E 00-	0.95178E-01	0.21660E00
0.18000E02-	0.15539E-02-	0.11800E 00-	0.11955E 00	0.19222E00
0.20000E02-	0.99179E-02-	0.12063E 00-	0.13055E 00	0.18122E00
0.22000E02-	0.16887E-01-	0.12097E 00-	0.13786E 00	0.17391E00

AVERAGE AND MAX. FLUX = 0.31177E 00 0.65646E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4880	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42947E 01	0.67402E 02	0:33512E 01	0.18690E 03	0.18170E 00	0.41139E-01

B4-4-3 E(BR---CO)

0.0 -	0.26612E-01-	0.13260E 00-	0.15921E 00	0.17843E00
0.20000E01-	0.26823E-01-	0.14279E 00-	0.16961E 00	0.16803E00
0.40000E01-	0.13260E-01	0.22755E 00	0.21429E	0.55193E00
0.60000E01	0.27216E-02	0.38148E 00	0.38420E 00	0.72184E00
0.80000E01	0.16250E-01	0.25814E 00	0.27439E 00	0.61202E00
0.10000E02	0.24525E-01	0.31468E-01	0.55994E-01	0.39363E00
0.12000E02	0.26364E-01-	0.48297E-01-	0.21933E-01	0.31570E00
0.14000E02	0.20758E-01-	0.83552E-01-	0.62795E-01	0.27484E00
0.16000E02	0.88164E-02-	0.11551E 00-	0.10669E 00	0.23095E00
0.18000E02-	0.24056E-02-	0.12936E 00-	0.13177E 00	0.20587E00
0.20000E02-	0.11391E-01-	0.13104E 00-	0.14243E 00	0.19521E00
0.22000E02-	0.18822E-01-	0.13070E 00-	0.14953E 00	0.18811E00

AVERAGE AND MAX. FLUX = 0.33764E 00 0.72184E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42079E 01	0.66041E 02	0.33512E 01	0.18690E 03	0.18927E 00	0.42853E-01

B4-4-1 E(BR---CO)

0.0 -	0.33302E-01-	0.15623E 00-	0.18953E 00	0.21527E00
0.20000E01-	0.31916E-01-	0.16938E 00-	0.20130E 00	0.20350E00
0.40000E01-	0.13520E-01	0.32851E 00	0.31499E 00	0.71979E00
0.60000E01	0.62691E-02	0.48117E 00	0.49044E 00	0.89524E00
0.80000E01	0.22164E-01	0.29108E 00	0.31325E 00	0.71805E00
0.10000E02	0.31118E-01	0.44663E-02	0.35584E-01	0.44038E00
0.12000E02	0.32057E-01-	0.76131E-01-	0.44075E-01	0.36072E00
0.14000E02	0.23874E-01-	0.11053E 00-	0.86654E-01	0.31815E00
0.16000E02	0.83645E-02-	0.14725E 00-	0.13888E 00	0.26592E00
0.18000E02-	0.51694E-02-	0.15926E 00-	0.16443E 00	0.24037E00
0.20000E02-	0.15629E-01-	0.15755E 00-	0.17318E 00	0.23162E00
0.22000E02-	0.24126E-01-	0.15485E 00-	0.17897E 00	0.22583E00

AVERAGE AND MAX. FLUX = 0.40480E 00 0.89524E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.42513E 01	0.66722E 02	0.33512E 01	0.18690E 03	0.18542E 00	0.41983E-01

B4-4-2 E(BR---CO)

0.0 -	0.29617E-01-	0.14365E 00-	0.17327E 00	0.19491E00
0.20000E01-	0.29210E-01-	0.15514E 00-	0.18435E 00	0.18384E00
0.40000E01-	0.13533E-01	0.27047E 00	0.25694E 00	0.62512E00
0.60000E01	0.41954E-02	0.42795E 00	0.43214E 00	0.80032E00
0.80000E01	0.18844E-01	0.27508E 00	0.29393E 00	0.66211E00
0.10000E02	0.27488E-01	0.20757E-01	0.48245E-01	0.41643E00
0.12000E02	0.28978E-01-	0.60570E-01-	0.31591E-01	0.33659E00
0.14000E02	0.22262E-01-	0.95627E-01-	0.73365E-01	0.29482E00
0.16000E02	0.87332E-02-	0.12962E 00-	0.12089E 00	0.24729E00
0.18000E02-	0.35637E-02-	0.14288E 00-	0.14645E 00	0.22174E00
0.20000E02-	0.13244E-01-	0.14321E 00-	0.15645E 00	0.21173E00
0.22000E02-	0.21186E-01-	0.14192E 00-	0.16311E 00	0.20507E00

AVERAGE AND MAX. FLUX = 0.36818E 00 0.80032E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.35138E 01	0.55147E 02	0.33512E 01	0.18690E 03	0.27142E 00	0.61454E-01

B4-3-9 (E(BR---CO)

0.0 -	0.20033E-01-	0.90703E-01-	0.11074E 00	0.13556E00
0.20000E01-	0.18848E-01-	0.88661E-01-	0.10751E 00	0.13878E00
0.40000E01-	0.80487E-02	0.19308E 00	0.18503E 00	0.43132E00
0.60000E01	0.37280E-02	0.28133E 00	0.28976E 00	0.53135E00
0.80000E01	0.13291E-01	0.17165E 00	0.18494E 00	0.43123E00
0.10000E02	0.18712E-01	0.97857E-02	0.28498E-01	0.27479E00
0.12000E02	0.19276E-01-	0.42189E-01-	0.22913E-01	0.22338E00
0.14000E02	0.14354E-01-	0.66907E-01-	0.52553E-01	0.19374E00
0.16000E02	0.51305E-02-	0.90773E-01-	0.85643E-01	0.16065E00
0.18000E02-	0.31022E-02-	0.98667E-01-	0.10177E 00	0.14452E00
0.20000E02-	0.95835E-02-	0.97171E-01-	0.10676E 00	0.12953E00
0.22000E02-	0.14774E-01-	0.93402E-01-	0.10818E 00	0.13811E00

AVERAGE AND MAX. FLUX = 0.24629E 00 0.53135E 00

L0	L1	N0	N1	ALFA0	ALFA1
0.3600	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.35572E 01	0.55828E 02	0.33512E 01	0.18690E 03	0.26484E 00	0.59964E-01

B4-3-10 E(BR---CO)

0.0 -	0.18788E-01-	0.88088E-01-	0.10488E 00	0.12758E00
0.20000E01-	0.17845E-01-	0.85756E-01-	0.10360E 00	0.12864E00
0.40000E01-	0.78005E-02	0.17813E 00	0.17033E 00	0.40257E00
0.60000E01	0.32762E-02	0.26442E 00	0.26770E 00	0.49994E00
0.80000E01	0.12331E-01	0.16407E 00	0.17640E 00	0.40864E00
0.10000E02	0.17523E-01	0.11288E-01	0.28811E-01	0.26105E00
0.12000E02	0.18160E-01-	0.38760E-01-	0.20600E-01	0.21164E00
0.14000E02	0.13632E-01-	0.62379E-01-	0.48747E-01	0.18349E00
0.16000E02	0.50069E-02-	0.84843E-01-	0.79836E-01	0.15240E00
0.18000E02-	0.27488E-02-	0.92485E-01-	0.95233E-01	0.13701E00
0.20000E02-	0.88685E-02-	0.91324E-01-	0.10019E 00	0.13205E00
0.22000E02-	0.13784E-01-	0.88116E-01-	0.10190E 00	0.13034E00

AVERAGE AND MAX. FLUX = 0.23224E 00 0.49994E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.34271E 01	0.53786E 02	0.33512E 01	0.18690E 03	0.28534E 00	0.64605E-01

B4-3-7 E(BR---CO)

0.0	-0.23068E-01	-0.10182E 00	-0.12489E	0.15532E00
0.20000E01	-0.21240E-01	-0.95239E-01	-0.116480 00	0.16373E00
0.40000E01	-0.85695E-02	0.23079E 00	0.22222E 00	0.50243E00
0.60000E01	0.48973E-02	0.32242E 00	0.32731E 00	0.60752E00
0.80000E01	0.15668E-01	0.18896E 00-	0.20463E 00	0.48484E00
0.10000E02	0.21610E-01	0.53024E-02	0.26912E-01	0.30712E00
0.12000E02	0.21966E-01-	0.507480-01-	0.28782E-01	0.25142E00
0.14000E02	0.16054E-01-	0.77960E-01-	0.61907E-01	0.21830E00
0.16000E02	0.53670E-02-	0.10525E 00-	0.99878E-01	0.18033E00
0.18000E02-	0.40091E-02-	0.11366E 00-	0.11767E 00	0.16253E00
0.20000E02-	0.11354E-01-	0.11131E 00-	0.12267E 00	0.15754E00
0.22000E02-	0.17203E-01-	0.10615E 00-	0.12335E 00	0.15686E00

AVERAGE AND MAX. FLUX = 0.28020E 00 0.60752E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.34704E 01	0.54467E 02	0.33512E 01	0.18690E 03	0.27825E 00	0.63000E-01

B4-3-8 E(BR---CO)

0.0	-0.21447E-01	-0.95921E-01	-0.11737E 00	0.14479E00
0.20000E01	-0.19972E-01	-0.91817E-01	-0.11179E 00	0.15037E00
0.40000E01	-0.83065E-02	0.21043E 00	0.20213E 00	0.46428E00
0.60000E01	0.42608E-02	0.30051E 00	0.30477E 00	0.56692E00
0.80000E01	0.14392E-01	0.17999E 00	0.19432E 00	0.45648E00
0.10000E02	0.20062E-01	0.78386E-02	0.27901E-01	0.29006E00
0.12000E02	0.20535E-01	-0.46144E-01	-0.25609E-01	0.23655E00
0.14000E02	0.15157E-01	-0.72053E-01	-0.56897E-01	0.20526E00
0.16000302	0.52524E-02	-0.97512E-01	-0.92260E-01	0.16990E00
0.18000E02	-0.35167E-02	-0.10567E 00	-0.10918E 00	0.15297E00
0.20000E02	-0.10403E-01	-0.10379E 00	-0.11419E 00	0.14797E00
0.22000E02	-0.15904E-01	-0.99369E-01	-0.11527E 00	0.14688E00

AVERAGE AND MAX. FLUX = 0.26216E 00 O.56692E 00

0.0	-0.27137E-01	-0.11615E 00	-0.14329E 00	0.18166E00
0.20000E01	-0.24312E-01	-0.10277E 00	-0.12708E 00	0.19787E00
0.40000E01	-0.90694E-02	0.28416E 00	0.27509E 00	0.60004E00
0.60000E01	0.66196E-02	0.37689E 00	0.38351E 00	0.70845E00
0.80000E01	0.18936E-01	0.20939E 00	0.22833E 00	0.55328E00
0.10000E02	0.25494E-01	-0.23979E-02	0.23096E-01	0.34804E00
0.12000E02	0.25496E-01	-0.62555E-01	-0.37060E-01	0.28789E00
0.14000E02	0.18197E-01	-0.92857E-01	-0.74660E-01	0.25029E00
0.16000E02	0.55346E-02	-0.12478E 00	-0.11925E 00	0.20570E00
0.18000E02	-0.53309E-02	-0.13367E 00	-0.13900E 00	0.18595E00
0.20000E02	-0.13795E-01	-0.13002E 00	-0.14382E 00	0.18113E00
0.22000E02	-0.20492E-01	-0.12283E 00	-0.14332E 00	0.18162E00

AVERAGE AND MAX. FLUX = 0.32495E 00 0.70845E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.33837E 01	0.53105E 02	0.33512E 01	0.18690E 03	0.29270E 00	0.66272E-01

B4-3-6 E(BR---CO)

0.0	-0.24944E-01	-0.10822E 00	-0.13346E 00	0.16746E00
0.20000E01	-0.22676E-01	-0.98913E-01	-0.12159E 00	0.17933E00
0.40000E01	-0.88289E-02	0.25499E 00	0.24616E 00	0.54708E00
0.60000E01	0.56689E-02	0.34764E 00	0.35331E 00	0.65423E00
0.80000E01	0.17163E-01	0.19879E 00	0.21595E 00	0.51688E00
0.10000E02	0.23400E-01	0.19788E-02	0.25379E-01	0.32630E00
0.12000E02	0.23604E-01	-0.56152E-01	-0.32549E-01	0.26837E00
0.14000E02	0.17061E-01	-0.84813E-01	-0.67752E-01	0.23317E00
0.16000E02	0.54617E-02	-0.11422E 00	-0.10876E 00	0.19217E00
0.18000E02	-0.46029E-02	-0.12289E 00	-0.12749E 00	0.17343E00
0.20000E02	-0.12468E-01	-0.11997E 00	-0.13244E 00	0.16848E00
0.22000E02	-0.18713E-01	-0.11390E 00	-0.13261E 00	0.16831E00

AVERAGE AND MAX. FLUX = 0.30092E 00 0.65423E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0150	0.5650	0.360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.32535E 01	0.51063E 02	0.33512E 01	0.18690E 03	0.31659E 00	0.71680E-01

B4-3-3 E(BR---CO)

0.0	-0.32854E-01	-0.13483E 00	-0.16769E 00	0.21900E00
0.20000E01	-0.28324E-01	-0.10979E 00	-0.13811E 00	0.24858E00
0.40000E01	-0.93655E-02	0.36452E 00	0.35515E 00	0.74185E00
0.60000E01	0.93404E-02	0.45112E 00	0.46046E 00	0.84715E00
0.800000E01	0.2368E-01	0.23214E 00	0.25583E 00	0.64252E00
0.10000E02	0.30951E-01	-0.15811E-01	0.15139E-01	0.40183E00
0.12000E02	0.30308E-01	-0.79372E-01	-0.49064E-01	0.33763E00
0.14000E02	0.20936E-01	-0.11401E 00	-0.93070E-01	0.29362E00
0.16000E02	0.54802E-02	-0.15279E 00	-0.14731E 00	0.23938E00
0.18000E02	-0.73979E-02	-0.16187E 00	-0.16927E 00	0.21742E00
0.20000E02	-0.17378E-01	-0.15601E 00	-0.17339E 00	0.21330E00
0.22000E02	-0.25203E-01	-0.14547E 00	-0.17068E 00	0.21602E00

AVERAGE AND MAX. FLUX = 0.38669E 00 0.84715E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BINO	BIN1	NKO	NK1	FOO	FO1
0.100003	010.32969E	010.51743E	020.33512E	010.18690E	03	
0.30831E	00	0.69806E-01				

B4-3-4 E(BR---CO)

0.0	-0.29734E-01	-0.12488E 00	-0.15461E 00	0.19853E00
0.20000E01	-0.26183E-01	-0.10657E 00	-0.13276E 00	0.22038E00
0.40000E01	-0.92642E-02	0.31991E 00	0.31064E 00	0.66378E00
0.60000E01	0.78124E-02	0.41104E 00	0.41886E 00	0.77200E00
0.80000E01	0.21072E-01	0.22064E 00	0.24171E 00	0.59485E00
0.10000E02	0.27974E-01	-0.81800E-02	0.19794E-01	0.37293E00
0.12000E02	0.27704E-01	-0.70199E-01	-0.42495E-01	0.31065E00
0.14000E02	0.19481E-01	-0.10243E 00	-0.82948E-01	0.27019E00
0.160000E02	0.55514E-02	-0.13741E 00	-0.13186E 00	0.2129E00
0.180000E02	-0.62397E-02	-0.14645E 00	-0.15269E	0.2045E00
0.20000E02	-0.15399E-01	-0.14185E 00	-0.15725E 00	0.19589E00
0.22000E02	-0.22617E-01	-0.13323E 00	-0.15585E 00	0.19729E00

AVERAGE AND MAX. FLUX = 0.35314E 00 0.77200E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.31668E 01	0.49701E 02	0.33512E 01	0.18690E 03	0.33417E 00	0.75662E-01

B4-3-1 E(BR---CO)

0.0	-0.41401E-01	-0.15831E 00	-0.19971E 00	0.27770E00
0.20000E01	-0.33473E-01	-0.10644E 00	-0.13992E 00	0.33749E00
0.40000E01	-0.88786E-02	0.49464E 00	0.48577E 00	0.96318E00
0.60000E01	0.14037E-01	0.55209E 00	0.56613E 00	0.10435E01
0.80000E01	0.31101E-01	0.25124E 00	0.28234E 00	0.75975E00
0.10000E02	0.39088E-01	-0.38083E-01	0.10058E-02	0.47842E00
0.12000E02	0.37161E-01	-0.10334E 00	-0.66177E-01	0.41123E00
0.14000E02	0.24419E-01	-0.14630E 00	-0.12188E 00	0.35553E00
0.16000E02	0.48083E-02	-0.19674E 00	-0.19193E 00	0.28548E00
0.18000E02	-0.10931E-01	-0.20533E 00	-0.21626E 00	0.26115E00
0.20000E02	-0.23140E-01	-0.19525E 00	-0.21839E 00	0.25902E00
0.22000E02	-0.32553E-01	-0.17778E 00	-0.21034E 00	0.26707E00

AVERAGE AND MAX. FLUX = 0.47741E 00 0.10435E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.3600	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.32102E 01	0.50382E 02	0.33512E 01	0.18690E 03	0.32520E 00	0.73630E-01

B4-3-2 E(BR---CO)

0.0	-0.36663E-01	-0.14607E 00	-0.18274E 00	0.24455E00
0.20000E01	-0.30761E-01	-0.11100E 00	-0.14176E 00	0.28552E00
0.40000E01	-0.92885E-02	0.42127E 00	0.41198E 00	0.83927E00
0.60000E01	0.11343E-01	0.49806E 00	0.50941E 00	0.93670E00
0.80000E01	0.26946E-01	0.24301E 00	0.26996E 00	0.69725E00
0.10000E02	0.34581E-01	-0.25750E-01	0.88318E-02	0.43612E00
0.12000E02	0.33414E-01	-0.90368E-01	-0.56954E-01	0.37033E00
0.14000E02	0.22580E-01	-0.12828E 00	-0.10570E 00	0.32159E00
0.16000E02	0.52630E-02	-0.17199E 00	-0.16673E 00	0.26056E00
0.18000E02	-0.89088E-02	-0.18094E 00	-0.18985E 00	0.23744E00
0.20000E02	-0.19879E-01	-0.17334E 00	-0.19322E 00	0.23407E00
0.22000E02	-0.28422E-01	-0.16007E 00	-0.18849E 00	0.23880E00

AVERAGE AND MAX. FLUX = 0.42729E 00 0.93670E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.24727 01	0.38807E 02	0.33512E 01	0.18690E 03		
0.54811E 00	0.12410E 00					

B4-2-8 F(ER---CO)

0.0	-0.23909E-01	-0.86827E-01	-0.11074E 00	0.16067E00
0.20000E01	-0.17758E-01	-0.84849E-02	-0.26243E-01	0.24516E00
0.40000E01	-0.38682E-02	0.29047E 00	0.28660E 00	0.55800E00
0.60000E01	0.87924E-02	0.29209E 00	0.30088E 00	0.57229E00
0.80000E01	0.18101E-01	0.11491E 00	0.13301E 00	0.40442E00
0.10000E02	0.22278E-01	-0.19234E-01	0.30443E-02	0.27445E00
0.12000E02	0.20751E-01	-0.52911E-01	-0.32161E-01	0.23925E00
0.14000E02	0.13150E-01	-0.80888E-01	-0.67738E-01	0.20367E00
0.16000E02	0.23337E-02	-0.11287E 00	-0.11054E 00	0.16087E00
0.18000E02	-0.65629E-02	-0.12145E 00	-0.127980 00	0.14343E00
0.20000E02	-0.13774E-01	-0.11815E 00	-0.13193E 00	0.13948E00
0.22000E02	-0.19490E-01	-0.10641E 00	-0.12590E 00	0.14551E00

AVERAGE AND MAX. FLUX = 0.27141E 00 0.57229E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.055	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.25161E 01	0.39488E 02	0.33512 01	0.18690E 03		
0.52937E 00	0.11986E 00					

B4-2-10 E(BR---CO)

0.0	-0.22327E-01	-0.81451E-01	-0.10378E 00	0.15066E00
0.20000E01	-0.16833E-01	-0.14837E-01	-0.31671E-01	0.22277E00
0.40000E01	-0.38450E-02	0.26922E 00	0.26537E 00	0.51981E00
0.60000E01	0.80738E-02	0.27625E 00	0.28433E 00	0.53877E00
0.80000E01	0.16868E-01	0.11249E 00	0.12935E 00	0.38379E00
0.10000E02	0.20857E-01	-0.17453E-01	0.34043E-02	0.25784E00
0.12000E02	0.19509E-01	-0.50110E-01	-0.30601E-01	0.22384E00
0.14000E02	0.12463E-01	-0.76120E-01	-0.63558E-01	0.19078E00
0.16000E02	0.22932E-02	-0.10571E 00	-0.10342E 00	0.15103E00
0.18000E02	-0.60445E-02	-0.11338E 00	-0.11943E 00	0.13502E00
0.20000E02	-0.12812E-01	-0.10990E 00	-0.12271E 00	0.13173E00
0.22000E02	-0.18123E-01	-0.98934E-01	-0.11706E 00	0.13738E00

AVERAGE AND MAX. FLUX = 0.25444E 00 0.53877E 00

LO	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.23859E 01	0.37446E 02	0.33512E 01	0.18690E 03	0.58869E 00	0.13329E 00

B4-2-7 E(BR---CO)

0.0	-0.27821E-01	-0.10010E 00	-0.12792E 00	0.18525E00
0.20000E01	-0.19996E-01	0.80645E-02	-0.11932E-01	0.30124E00
0.40000E01	-0.38781E-02	0.34356E 00	0.33968E 00	0.65285E00
0.60000E01	0.10599E-01	0.33077E 00	0.34137E 00	0.65455E00
0.80000E01	0.21160E-01	0.11997E 00	0.14113E 00	0.45431E00
0.10000E02	0.25783E-01	-0.23824E-01	0.19588E-02	0.31513E00
0.12000E02	0.23794E-01	-0.59820E-01	-0.36027E-01	0.27715E00
0.14000E02	0.14809E-01	-0.92649E-01	-0.77840E-01	0.23533E00
0.16000E02	0.24026E-02	-0.13055E 00	-0.12814E 00	0.18503E00
0.18000E02	-0.77355E-02	-0.14133E 00	-0.14906E 00	0.16411E00
0.20000E02	-0.16163E-01	-0.13850E 00	-0.15466E 00	0.15851E00
0.22000E02	-0.22878E-01	-0.12485W 00	-0.14773E 00	0.16544E00

AVERAGE AND MAX. FLUX = 0.31317E 00 0.65455E 00

LO	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0400	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.24293E 01	0.38127E 02	0.33512E 01	0.18690E 03	0.56786E 00	0.12857E 00

B4-2-8 E(BR----CO)

00.	-0.25723E-01	-0.92995E-01	-0.11872E 00	0.17208E00
0.20000E01	-0.18805E-01	-0.99309E-03	-0.19798E-01	0.27100E00
0.40000E01	-0.38816E-02	0.31499E 00	0.31111E 00	0.60190E00
0.60000E01	0.96241E-02	0.31013E 00	0.31975E 00	0.61055E00
0.80000E01	0.19517E-01	0.11743E 00	0.13695E 00	0.42774E00
0.10000E02	0.23904E-01	-0.21339E-01	0.25650E-02	0.29336E00
0.12000E02	0.22166E-01	-0.56122E-01	-0.33956E-01	0.25684E00
0.14000E02	0.13926E-01	-0.86343E-01	-0.72417E-01	0.21838E00
0.16000E02	0.23712E-02	-0.12106E 00	-0.11869E 00	0.17211E00
0.18000E02	-0.70841E-02	-0.13067E 00	-0.13775E 00	0.15305E00
0.20000E02	-0.14879E-01	-0.12759E 00	-0.14247E 00	0.14833E00
0.22000E02	-0.21058E-01	-0.11496E 00	-0.13602E 00	0.15478E00

AVERAGE AND MAX. FLUX = 0.29080E 00 0.61055E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22992E 01	0.36084E 02	0.33512E 01	0.18690E 03	0.63396E 00	0.14354E 00

B4-2-5 E(BR---C0)

0.0	-0.33188E-01	-0.11794E 00	-0.15113E 00	0.21901E00
0.20000E01	-0.22930E-01	0.34001E-01	0.11711E-01	0.38121E00
0.40000E01	-0.37668E-02	0.41741E 00	0.41364E 00	0.78378E00
0.60000E01	0.13154E-01	0.38201E 00	0.39517E 00	0.76530E00
0.80000E01	0.25387E-01	0.12442E 00	0.14981E 00	0.51994E00
0.10000E02	0.30574E-01	-0.30177E-01	0.39766E-03	0.37053E00
0.12000E02	0.27908E-01	-0.69045E-01	-0.41137E-01	0.32900E00
0.14000E02	0.16990E-01	-0.10873E 00	-0.91744E-01	0.27839E00
0.16000E02	0.24271E-02	-0.15487E 00	-0.15245E 00	0.21769E00
0.18000E02	-0.94364E-02	-0.16867E 00	-0.17811E 00	0.19203E00
0.20000E02	-0.19482E-01	-0.16654E 00	-0.18602E 00	0.18411E00
0.22000E02	-0.27569E-01	-0.15017E 00	-0.17773E 00	0.19240E00

AVERAGE AND MAX. FLUX = 0.37014E 00 0.73781E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.23425E 01	0.36765E 02	0.33512E 01	0.18690E 03	0.61070E 00	0.13827E 00

B4-2-6 E(BR---CO)

0.0	0.30277E-01	-0.10833E 00	-0.13861E 00	0.20067E00
0.20000E01	-0.21360E-01	0.19363E-01	-0.19979E-02	0.33728E00
0.40000E01	-0.38461E-02	0.37722E 00	0.37337E 00	0.71265E00
0.60000E01	0.11756E-01	0.35453E 00	0.36629E 00	0.70557E00
0.80000E01	0.23089E-01	0.12240E 00	0.14549E 00	0.48477E00
0.10000E02	0.27977E-01	-0.26749E-01	0.12286E-02	0.34051E00
0.12000E02	0.25685E-01	-0.64095E-01	-0.38410E-01	0.30087E00
0.14000E02	0.15821E-01	-0.10002E 00	-0.84198E-01	0.25508E00
0.16000E02	0.24235E-02	-0.14166E 00	-0.13924E 00	0.20005E00
0.18000E02	-0.85075E-02	-0.15381E 00	-0.16232E 00	0.17696E00
0.20000E02	-0.17674E-01	-0.15129E 00	-0.16897E 00	0.17032E00
0.22000E02	-0.25016E-01	-0.13642E 00	-0.16144E 00	0.17784E00

AVERAGE AND MAX. FLUX = 0.33928E 00 0.71265E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22124E 01	0.34723E 02	0.33512E 01	0.18690E 03	0.68466E 00	0.15502E 00

B4-2-3 E(BR---C0)

0.0	-0.41009E-01	-0.14279E 00	-0.18380E 00	0.26863E00
0.20000E01	-0.26840E-01	0.82384E-01	0.55544E-01	0.50797E00
0.40000E01	-0.33131E-02	0.52635E 00	0.52303E 00	0.97546E00
0.60000E01	0.17044E-01	0.45095E 00	0.46799E 00	0.92042E00
0.80000E01	0.31599E-01	0.12445E 00	0.15605E 00	0.60847E00
0.10000E02	0.37508E-01	-0.38653E-01	-0.11452E-02	0.45128E00
0.12000E02	0.33753E-01	-0.81320E-01	-0.47567E-01	0.40486E00
0.14000E02	0.19947E-01	-0.13182E 00	-0.11187E 00	0.34055E00
0.16000E02	0.23346E-02	-0.19049E 00	-0.18816E 00	0.26427E00
0.18000E02	-0.11993E-01	-0.20911E 00	-0.22110E 00	0.23132E00
0.20000E02	-0.24430E-01	-0.20827E 00	-0.23270E 00	0.21973E00
0.22000E02	-0.34553E-01	-0.18745E 00	-0.22201E 00	0.23042E00

AVERAGE AND MAX. FLUX = 0.45242E 00 0.97546E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.2400	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.22558E 01	0.35403E 02	0.33512E 01	0.18690R 03	0.65858E 00	0.14911E 00

B4-2-4 E(BR---C0)

0.0	-0.36697E-01	-0.12927E 00	-0.16596E 00	0.24120E00
0.20000E01	-0.24743E-01	0.53864E-01	0.29121E-01	0.43628E00
0.40000E01	-0.36079E-02	0.46615E 00	0.46254E 00	0.86970E00
0.60000E01	0.14874E-01	0.41392E 00	0.42879E 00	0.83595E00
0.80000E01	0.28167E-01	0.12548E 00	0.15365E 00	0.56081E00
0.10000E02	0.33694E-01	-0.34153E-01	-0.45895E-03	0.40670E00
0.12000E02	0.30554E-01	-0.74769E-01	-0.44215E-01	0.36295E00
0.14000E02	0.18350E-01	-0.11917E 00	-0.10082E 00	0.30635E00
0.16000E02	0.24028E-02	-0.17084E 00	-0.16844E 00	0.23873E00
0.18000E02	-0.10574E-01	-0.18671E 00	-0.19728E 00	0.20988E00
0.20000E02	-0.21685E'01	-0.18509E 00	-0.20678E 00	0.20039E00
0.22000E02	-0.30677E-01	-0.16680E 00	-0.19748E 00	0.20969E00

AVERAGE AND MAX. FLUX = 0.40716E 00 0.86970E 00

LO	LI	KO	KI	ALFAO	ALFAI
0.2400	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

0.10000E 01 0.21256E 01 0.33361E 02 0.33512E 01 0.18690E 03
0.74169E 00 0.16793E 00

AVERAGE AND MAX. FLUX = 0.58176E 00 0.12810E 01

LU	LI	KU	KI	ALFAO	ALFAI
0.2400	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BINO	BINI	NKO	NKI	FOO	FOI
0.10000E 01	.21256E 01	0.33361E 02	0.33512E 01	0.18690E 03	0.74169E 00	0.16793E 00

B4-2-1 E(BR————CO)

0.0	-0.53524E-01	-0.17986E 00	-0.23338E 00	0.34838E 00
0.20000E 01	-0.31945E-01	0.20089E 00	0.16894E 00	0.75071E 00
0.40000E 01	-0.17949E-02	0.70099E 00	0.69920E 00	0.12810E 01
0.60000E 01	0.23656E-01	0.54065E 00	0.56431E 00	0.11461E 01
0.80000E 01	0.4157 E-01	0.10328E 00	·0.14486E 00	0.72662E 00
0.10000E 02	0.48372E-01	-0.47700E-01	0.67209E-03	0.58244E 00
0.12000E 02	0.42612E-01	-0.95737E-01	-0.53124E-01	0.52864E 00
0.14000E 02	0.24037E-01	-0.16624E 00	-0.14220E 00	0.43956E 00
0.16000E 02	0.19695E-02	-0.24683E 00	-0.24486E 00	0.33690E 00
0.18000E 02	-0.16158E-01	-0.27589E 00	-0.29204E 00	0.28972E 00
0.20000E 02	-0.32605E-01	-0.27915E 00	-0.31175E 00	0.27001E 00
0.22000E 02	-0.46229E-01	-0.25022E-01	-0.29645E 00	-0.28531E 00
0.28531E 00				

AVERAGE AND MAX.FLUX = 0.58176E 00 0.12810E 01

LO	LI	KO	KI	ALFAO	ALFAI
0.2400	0.0100	0.5650	0.0360	0.18550E-03	0.42000E-03

NH	BINO	BINI	NKO	NKI	FOO	FOI

0.10000E 01 0.21690E 01 0.34042E 02 0.33512E 01 0.18690E 03
0.71232E 00 0.16128E 00

B4-2-2 E(BR---CO)

0.0	-0.46443E-01	-0.15922E 00	-0.20567E 00	0.30554E00
0.20000E01	-0.29250E-01	0.12637E 00	0.97118E-01	0.60612E00
0.40000E01	-0.27782E-0	2 0.60236E 0	0 0.59959E 00	0.11086E01
0.60000E01	0.19860E-01	0.49351E 00	0.51337E 00	0.10224E01
0.80000E01	0.35935E-01	0.11893E 00	0.15486E 00	0.66387E00
0.10000E02	0.42271E-01	-0.43438E-01	-0.11677E-02	0.50784E00
0.12000E02	0.37686E-01	-0.88566E-01	-0.50880E-01	0.45813E00
0.14000E02	0.21828E-01	-0.14732E 00	-0.12549E 00	0.38352E00
0.16000E02	0.21993E-02	-0.21519E 00	-0.21299E 00	0.25744E00
0.20000E02	-0.27946E-01	-0.23827E 00	-0.26621E 00	0.24279E00
0.22000E02	-0.39538E-01	-0.21404E 00	-0.25358E 00	0.25543E00

AVERAGE AND MAX. FLUX = 0.50901E 00 0.11086E 01

L0	L1	N0	N1	ALFIA0	ALFA1
0.1200	0.0450	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.14316E 01	0.22467E 02	0.33512E 01	0.18690E 03	0.16353E 01	0.37025E 00

B4-1-9 E(BR---C0)

0.0	-0.29475E-01	-0.11203E 00	-0.14150E 00	0.16072E 00
0.20000E01	-0.13913E-01	0.24387E 00	0.22995E 00	-0.53218E-00
0.40000E01	0.16057E-02	0.40319E-00	-0.40479E 00	-0.70702E-00
0.60000E01	0.13970E-01	0.23872E 00	0.25269E 00	-0.55492E-00
0.80000E01	0.22300E-01	-0.30581E-01	-0.82805E-02	-0.29395E-00
0.10000E02	0.25013E-01	-0.28004E-01	-0.29913E-02	-0.29923E-00
0.12000E02	0.21061E-01	-0.36359E-01	-0.15299E-01	-0.28693E-00
0.14000E02	0.10524E-01	-0.72308E-01	-0.61784E-01	-0.24044E-00
0.16000E02	0.35814E-03	-0.11792E 00	-0.11756E 00	-0.18467E-00
0.18000E02	-0.82470E-02	-0.14441E 00	-0.15266E 00	-0.14957E-00
0.20000E02	-0.17377E-01	-0.16107E 00	-0.17844E 00	-0.12378E-00
0.22000E02	-0.26044E-01	-0.15531E 00	-0.18135E 00	-0.12087E-00

AVERAGE AND MAX. FLUX = 0.30223E 00 0.70702E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.14749E 01	0.23148E 02	0.33512E 01	0.18690E 03	0.15405E 01	0.34879E 00

B4-1-10 E(BR---C0)

0.0	-0.27230E-01	-0.10059E 00	-0.12782E 00	0.15351E00
0.20000E01	-0.13125E-01	0.21581E 00	0.20269E 00	0.48402E00
0.40000E01	0.12896E-02	0.36988E 00	0.37117E 00	0.65251E00
0.60000E01	0.12858E-01	0.22397E 00	0.23682E 00	0.51816E00
0.80000E01	0.20696E-01	-0.20353E-01	0.34333E-03	0.28168E00
0.10000E02	0.23294E-01	-0.24412E-01	-0.11180E-02	0.28022E00
0.12000E02	0.19700E-01	-0.34471E-01	-0.14772E-01	0.26656E00
0.14000E02	0.99836E-02	-0.68902E-01	-0.58919E-01	0.22242E00
0.16000E02	0.40118E-03	-0.11151E 00	-0.11111E 00	0.17023E00
0.18000E02	-0.77291E-02	-0.13530E 00	-0.14303E 00	0.13830E00
0.20000E02	-0.16213E-01	-0.14902E 00	-0.16524E 00	0.11610E00
0.22000E02	-0.24114E-01	-0.14178E 00	-0.16590E 00	0.11544E00

AVERAGE AND MAX. FLUX = 0.28133E 00 0.65251E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0350	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13448E 01	0.21106E 02	0.33512E 01	0.18690E 03	0.18531E 01	0.41956E 00

B4-1-7 E(BR---C0)

0.0	-0.35140E-01	-0.14104E 00	-0.17618E 00	0.17876E00
0.20000E 01	-0.15906E-01	0.31421E 00	0.29831E 00	0.65325E00
0.40000E 01	0.24016E-02	0.48728E 00	0.48968E 00	0.84462E00
0.60000E 01	0.16780E-01	0.27640E 00	0.29318E 00	0.64812E00
0.80000E 01	0.26353E-01	-0.56229E-01	-0.29876E-01	0.32506E00
0.10000E 02	0.29353E-01	-0.37242E-01	-0.78898E-02	0.34705E00
0.12000E 02	-0.24498E-01	-0.41373E-01	-0.16876E-01	0.33806E00
0.14000E 02	0.11882E'01	-0.81050E-01	-0.69168E-01	0.28577E00
0.16000E 02	0.23708E-03	-0.13409E 00	-0.13385E 00	0.22109E00
0.18000E 02	-0.95622E-02	-0.16725E 00	-0.17681E 00	0.17813E00
0.20000E 02	-0.20313E-01	-0.19121E 00	-0.21153E 00	0.14341E00
0.22000E 02	-0.30900E-01	-0.18926E 00	-0.22016E 00	0.13478300

AVERAGE AND MAX. FLUX = 0.35494E 00 0.84462E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.04000.0360			0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.13882E 01	0.21787E 02	0.33512E 01	0.18690E 03	0.17391E 01	0.39375E 00

B4-1-8 E(BR---C0)

0.0	-0.32080E-00	-0.12534E 00	-0.15752E 00	0.16905E00
0.20000E 01	-0.14830E-01	0.27619E	0.26136E 00	0.58783E00
0.40000E 01	0.19708E-02	0.44185E 00	0.44382E 00	0.77029E00
0.60000E 01	0.15261E-01	0.25602E 00	0.27128E 00	0.59775E00
0.80000E 01	-0.24163E-01	-0.42356E-01	-0.18193E-01	0.30828E00
0.10000E 02	0.27008E-01	-0.32237E-01	-0.52292E-02	0.32124E00
0.12000E 02	0.22642E-01	-0.38647E-01	-0.16005E-01	0.31046E00
0.14000E 02	0.11150E-01	-0.76317E-01	-0.65166E-01	0.26130E00
0.16000E 02	0.30444E-03	-0.12535E 00	-0.12505E 00	0.20142E00
0.18000E 02	-0.88509E-02	-0.15493E 00	-0.16378E 00	0.16269E00
0.20000E 02	-0.18728E-01	-0.17495E 00	-0.19368E 00	0.13279E00
0.22000E 02	-0.28278E-01	-0.17094E 00	-0.19921E 00	9.12726E00

AVERAGE AND MAX. FLUX = 0.32647E 00 0.77029E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0250	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.12580E 01 0.19744E 02 0.33512E 01 0.18690E 03
0.21175E 01 0.47943E 00

B4-1-5 E(BR---C0)

0.0	-0.4328E-01	-0.18285E 00	-0.22608E 00	0.20385E00
0.20000E01	-0.18701E-01	0.41676E 00	0.39805E 00	0.82798E00
0.40000E01	0.35730E-02	0.60755E 00	0.61112E 00	0.10410E01
0.60000E01	0.20805E-01	0.32958E 00	0.35039E 00	0.78031E00
0.80000E01	0.32130E-01	-0.94142E-01	-0.62012E-01	0.36791E00
0.10000E02	0.35526E-01	-0.50559E-01	-0.15034E-01	0.41489E00
0.12000E02	0.29368E-01	-0.48434E-01	-0.19065E-01	0.41086E00
0.14000E02	0.13777E-01	-0.93310E-01	-0.79533E-01	0.35039E00
0.16000E02	0.50932E-04	-0.15686E-00	-0.15681E 00	0.27312E00
0.18000E02	-0.11430E-01	-0.19962E 00	-0.21105E 00	0.21888E00
0.20000E02	-0.24489E-01	-0.23420E 00	-0.25869E 00	0.17124E00
0.22000E02	-0.37833E-01	-0.23791E 00	-0.27574E 00	0.15418E00

AVERAGE AND MAX. FLUX = 0.42993E 00 0.10410E 01

L0	L1	N0	N1	ALFA0	ALFA1
0.1200	0.0300	0.5650	0.0360	0.18550E-02	0.42000E-03

NH BIN0 BIN1 NK0 NK1 FO0 FO1

0.10000E 01 0.13014E 01 0.20425E 02 0.33512E 01 0.18690E 03
0.19787E 01 0.448800E 00

B4-1-6 E(BR---C0)

0.0	-0.38790E-01	-0.15984E 00	-0.19863E 00	0.19022E00
0.20000E01	-0.17179E-01	0.36001E 00	0.34284E 00	0.73168E00
0.40000E01	0.29229E-02	0.54152E 00	0.54445E 00	0.93330E00
0.60000E01	0.18595E-01	0.30058E 00	0.31918E 00	0.70803E00
0.80000E01	0.28964E-01	-0.73044E-01	-0.44080E-01	0.34477E00
0.10000E02	0.32145E-01	-0.43241E-01	-0.110960-01	0.37775E00
0.12000E02	0.26704E-01	-0.44612E-01	-0.17908E-01	0.37094E00
0.14000E02	0.12746E-01	-0.86655E-01	-0.73909E-01	0.31494E00
0.16000E02	0.15508E-03	-0.14444E 00	-0.14429E 00	0.24456E00
0.18000E02	-0.10409E-01	-0.18190E 00	-0.19231E 00	0.19654E00
0.20000E02	-0.22202E-01	-0.21060E 00	-0.23280E 00	0.15605E00
0.22000E02	-0.34028E-01	-0.21115E 00	-0.24518E 00	0.14367E00

AVERAGE AND MAX. FLUX = 0.38885E 00 0.93330E 00

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0150	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.11713E 01	0.18382E 02	0.33512E 01	0.18690E 03	0.24428E 01	0.55309E 00

B4-1-3 E(BR---C0)

0.0	-0.55828E-01	-0.24996E 00	-0.30579E 00	0.23929E00
0.20000E01	-0.22813E-01	0.58643E 00	0.56362E 00	0.11087E01
0.40000E01	0.55536E-02	0.79622E 00	0.80177E 00	0.13469E01
0.60000E01	0.27103E-01	0.40856E 00	0.43566E 00	0.98075E00
0.80000E01	0.41041E-01	-0.15994E 00	-0.11890E 00	0.42619E00
0.10000E02	0.44986E-01	-0.71844E-01	-0.26858E-01	0.51823E00
0.12000E02	0.36759E-01	-0.58191E-01	-0.21431E-01	0.52365E00
0.14000E02	0.16526E-01	-0.11052E 00	-0.93994E-01	0.45109E00
0.16000E02	-0.26674E-03	-0.19031E 00	-0.19058E 00	0.35450E00
0.18000E02	-0.14237E-01	-0.24892E 00	-0.26316E 00	0.28192E00
0.20000E02	-0.30880E-01	-0.30150E 00	-0.33238E 00	0.21270E00
0.22000E02	-0.48628E-01	-0.31535E 00	-0.36398E 00	0.18110E00

AVERAGE AND MAX. FLUX = 0.54508E 00 0.13469E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0200	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.12147E 01	0.19063E 02	0.33512E 01	0.18690E 03	0.22714E 01	0.51429E 00

B4-1-4 E(BR---C0)

0.0	-0.48750E-01	-0.21187E 00	-0.26062E 00	0.22008E 00
0.20000E01	-0.20545E-01	0.48945E 00	0.46890E	0.94960E 00
0.40000E01	0.44142E-02	0.68995E 00	0.69437E 00	0.11751E 01
0.60000E01	0.23561E-01	0.36484E 00	0.38841E 00	0.86911E 00
0.80000E01	0.36053E-01	-0.12177E 00	-0.85720E-01	0.39498E 00
0.10000E02	0.39701E-01	-0.59755E-01	-0.20055E-01	0.46065E 00
0.12000E02	0.32643E-01	-0.52928E-01	-0.20285E-01	0.46042E 00
0.14000E02	0.15018E-01	-0.10121E 00	-0.86192E-01	0.39451E 00
0.16000E02	-0.83845E-04	-0.17191E 00	-0.17199E 00	0.30871E 00
0.18000E02	-0.12681E-01	-0.22145E 00	-0.23413E 00	0.24657E 00
0.20000E02	-0.27313E-01	-0.26365E 00	-0.29096E 00	0.18974W 00
0.22000E02	-0.42568E-01	-0.27154E 00	-0.31411E 00	0.16659E 00

AVERAGE AND MAX. FLUX = 0.48070E 00 0.11751E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0050	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.10845E 01	0.17021E 02	0.33512E 01	0.18690E 03		
		0.28493E 01				0.64512E 00

B4-1-1 E(BR--C0)

0.0	-0.78568E-01	-0.38326E 00	-0.46183E 00	0.28267E00
0.20000E01	-0.29339E-01	0.92628E 00	0.89694E 00	0.16414E10
0.40000E01	0.97233E-02	0.11462E 01	0.11559E 01	0.19004E01
0.60000E01	0.38519E-01	0.53897E 00	0.57749E 00	0.13220E01
0.80000E01	0.56654E-01	-0.30755E-00	-0.25090E 00	0.49360E00
0.10000E02	0.61291E-01	-0.11601E 00	-0.54718E-01	0.68978E00
0.12000E02	0.49190E-01	-0.71739E-01	-0.22549E-01	0.72195E00
0.14000E02	0.20588E-01	-0.13244E-00	-0.11185E 00	0.63264E00
0.16000E02	-0.98192E-03	-0.23987E 00	-0.24085E 00	0.50365E00
0.18000E02	-0.18744E-01	-0.33030E 00	-0.34904E 00	0.39546E00
0.20000E02	-0.41680E-01	-0.42238E 00	-0.46406E 00	0.28044E00
0.22000E02	-0.67826E-01	-0.46248E 00	-0.53030E 00	0.21420E00

AVERAGE AND MAX. FLUX = 0.74450E 00 0.19004E 01

L0	L1	K0	K1	ALFA0	ALFA1
0.1200	0.0100	0.5650	0.0360	0.18550E-02	0.42000E-03

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.11279E 01	0.17702E 02	0.33512E 01	0.18690E 03		
0.26343E 01	0.59645E 00					

B4-1-2 E(BR---C0)

0.0	-0.65267E-01	-0.30292E 00	-0.36819E 00	0.26118E00
0.20000E01	-0.25661E-01	0.72257E 00	0.69691E 00	0.13263E01
0.40000E01	0.71888E-02	0.93958E 00	0.94676E 00	0.15761E01
0.60000E01	0.31838E-01	0.46432E 00	0.49615E 00	0.11255E01
0.80000E01	0.47606E-01	-0.21635E 00	-0.16875E 00	0.46062E00
0.10000E02	0.51890E-01	-0.88910E-01	-0.37020E-01	0.59235E00
0.12000E02	0.42077E-01	-0.64356E-01	-0.22278E-01	0.60709E00
0.14000E02	0.18368E-01	-0.12121E 00	-0.10284E 00	0.52653E00
0.16000E02	-0.53461E-03	-0.21287E 00	-0.21340E 00	0.41597E00
0.18000E02	-0.16208E-01	-0.28422E 00	-0.30043E 00	0.32894E00
0.20000E02	-0.35505E-01	-0.35197E 00	-0.38748E 00	0.24190E00
0.22000E02	-0.56666E-01	-0.37519E 00	-0.43185E 00	0.19752E00

AVERAGE AND MAX. FLUX = 0.62937E 00 0.15761E 01

Symboles:

S: South
E: East

B4-4-10 E(BR--CO)

BR: Bricks
CO: Cork
AS: Asbestos
CR: Concrete

Column,

1	2	3	4	5
0.0	-0.15232E-01	-0.85340E-01	-0.100573 00	0.11303E 00
0.20000E 01	-0.16645E-01	-0.91643E-01	-0.10829E 00	0.10531E 00
0.40000E 01	-0.10117E-01	0.97419E-01	0.87302E-01	0.30090E 00
0.60000E 01	-0.10085E-02	0.20877E 00	0.20777E 00	0.42137E 00
0.80000E 01	0.75088E-02	0.16898E 00	0.17649E 00	0.39009E 00
0.10000E 02	0.13446E-01	0.47552E-01	0.60997E-01	0.27460E 00
0.12000E 02	0.15743E-01	-0.10165E-01	0.55784E-02	0.21918E 00
0.14000E 02	0.13616E-01	-0.39641E-01	-0.26025E-01	0.18757E 00
0.16000E 02	0.73693E-02	-0.62828E-01	-0.55459E-01	0.15814E 00
0.18000E 02	0.66001E-03	-0.75923E-01	-0.75263E-01	0.13834E 00
0.20000E 02	-0.51414E-02	-0.80735E-01	-0.85876E-01	0.12772E 00
0.22000E 02	-0.10146E-01	-0.82972E-01	-0.93118E-01	0.12048E 00

AVERAGE AND MAX. FLUX = 0.21360E 00 0.42137E 00

Column,

1 Day time, hours, (0 Corresponds to 6 am)

2 Dimensionless flux due-to O_a( )

3 Dimensionless flux due-to R_l ( )

4 Dimensionless flux due-to $O_a + R_l$

5 Total dimensionless heat flux due to steady state and harmonic terms,

Sample output

First Line

L0	L1	K0	K1	ALFA0	ALFA1
0.4800	0.0500	0.5650	0.0360	0.18550E-02	0.42000E-03

L0, L1 — Thickness of out-door and in-door layers, m

K0, K1 — Thermal conductivities of first and second layers, kcal/m h C.

ALFA0 Thermal diffusivities of first and
ALFA1 second layers, m^2/h.

Second Line

NH	BIN0	BIN1	NK0	NK1	FO0	FO1
0.10000E 01	0.45983E01	0.72168E02	0.33512E01	0.18690E03	0.15849E00	0.35885E-01

NH — Ratio of heat transfer coefficents, R_h

BIN0, BIN1 — Biot number for first and second layers, h_r. L/K0 and h_r.L/K1

NK0, NK1 — Dimensionless relations, $\alpha h_r^2 \tau_{cy}/k^2$, for first and second layer

FO0 Fourier numbers for first and
FO1 second layers

TABLES	WALL MATERIALS AND DIMENSIONS	ORIENTATION
A1-1-1 to A1-1-8 $N_l=10$ $R_h=1$ $O_r=0$	Flux distribution for wall of bricks and cork L_{Cork} 1 cm L_{Brick} 5--20(5) cm Cork is placed on outdoor face, (A-1-1-1 to A1-1-4) Cork is placed on indoor face, (A1-1-5 to A1-1-8)	SOUTH
A1-2-1 to A1-2-8	Same as above except Asbestos for the insulating layer.	SOUTH
B15-1 to B15-4 $N_l=10$ $T_h=1$ $O_r=0$	Flux distribution for wall of bricks and gypsum $L_{Gypsium}=1$ cm $L_{Brick}=$ 5 to 20(5) Gypsum is placed on the outer face.	SOUTH
B16-1 to B16-4	Same as above except brick layer is changed by concrete. Gypsium is placed indoor.	SOUTH

TABLES	WALL MATERIALS AND DIMENSIONS	ORIENTATION
B4−1−1 to B4−1−10 $N_l=10$ $R_h=1$ $\Theta_r=0$	Flux distribution for wall of bricks and cork of 12 cm brick and 0.5 to 5 (0.5) cm cork, $L_{Brick}=12$ cm $L_{Cork}=0.5$ to 5	EAST
B4−2−1 to B4−2−10	Same as above except $L_{Brick}=24$cm	EAST
B4−3−1 to B4−3−10	Same as above except $L_{Brick}=36$ cm	EAST
B4−4−1 to B4−1−10	Same as above except L_{Brick} = 48 cm	EAST
B5−1−1 to B5−1−10 $N_l=10$ $R_h=1$	Flux distribution for wall of bricks and cork of 12 cm brick and 0.5 to 5 (0.5) cm cork $L_{BRICK}=12$cm $L_{Cork}=0.5$ to 5	SOUTH
B5−2−1 to B5−2−10	Same as above except $L_{Brick}=24$ cm	SOUTH
B5−3−1 to B5−3−10	Same as above except $L_{Brick}=36$ cm	SOUTH
B5−4−1 to B5−4−10	Same as above except $L_{Brick}=48$ cm	SOUTH

APPENDIX D

SOME COMPUTER RESULTS FOR INDOORS FLUX VARIATION WITH TIME

MATERIAL	$10^3 k$ w/cm K	ϱ kg/m³	c kWs/kg c
Asbestos (fiber)	1.1	470	0.816
Asbestos (sheet)	1.163	733	0.816
Asbestos (cement)	9.18	400	
Asbestos (board)	1.55	2447	0.816
Asphalt	6.977	2110	2.09
Brick (building)	6.569	1523	0.837
Brick (face)	12.98	2082	0.837
Brick (masonry)	2.67	800	
		1500	
Chalk	9.30	2000	0.879
Coal	1.86	1400	1.306
Concrete	7.26	1950	0.837
Concrete (reinforced)	15.47	2200	0.838
Concrete (sandgravelágs)	1.731	2243	0.879
Cement (morter or plaster)	7.217	1858	0.795
Cork (plate)	0.418	177	2.030
Cotton (fiber)	0.375	12–32	1.298
Fire brick	1.395	550	
Glass	7.44	2660	0.67
Glass fiber	3.606	64.07	0.67
Glass wool	0.372	200	0.67
Gypsum (board)	4.326	2500	1.084
Gypsum (plaster)	8.077	1682	1.088
Iron	628	7220	0.502
Marble	0.130	2700	0.419
Mica	5.814	290	0.879
Mineral wool	0.465	200	0.921
Wood (hard)	1.586	728	2.386
Wood (oak)	1.627	769	2.09
Porcelain	10.4	2400	1.088
Portland cement	3.023	1900	1.130
Refractory clay	10.35	1845	1.088
Rubber	1.628	1200	1.381
Sand (dry)	3.256	1500	0.795
Steel	453	7900	0.461

APPENDIX C

PROPERTIES OF SOME BUILDING AND INSULATING MATERIALS

```
SUBROTYINE EXPENS (D1, D2, D3, D4, D5, D6)
COMMON / C / EEITA, ZITA, KABA
COMMON / D / NQAV, NQMAX
REAL NQAV, NQMAX, KABA
CW0 = D3
CW1 = D4
D5 = KABA + CW0 * D1 + CW1 * D2 + EEITA * NQMAX + ZITA * NQAV
D6 = KABA + CW0 + CW0 * CW1 * D2 + (EEITA + ZITA) * NQAV
WRITE (3,5) D5, D6, D1, D2
5 FORMAT (2X, ' TOTAL COST WITH NPEAK AND NAVERAGE = ', 2E12.5
* ,/, 2X, ' LAYERS THICKNESSES AS BASIS OF COST CAL. = ', 2E12.51
RETURN
END
```

```
      SUBROUTINE EXPENS (D1, D2, D3, D4, D5, D6)
      COMMON/ C / EEITA, ZITA, DABA
      COMMON / D / NOAV, NQMAX
      REAL NQAV, NQMAX, KABA
      CW0 = 03
      CW1 = D4
      D5 = KABA + CW0 * D1 + CW1 * D2 + EEITA * NQMAX + ZITA* NQAV
      D6 = KABA = CW0 * D1 + CW1 * D2 + (EEITA + ZITA) * NQAV
      WHRITE (3,5) D5, D6, D1, D2
    5 FORMAT (2X, ' TOTAL COST WITH NPEAD AND NAVERAGE = ', 2E12.5
     * ,/,2X, ' LAYERS THICKNESSES AS BASIS OF COST CAL.= ', 2EQW.5)
      RETURN
      END
```

```
      SUBROUTINE EXPENS (D1, D2, D3, D4, D5, D6)
      COMMON/ C / EEITA, ZITA, DABA
      COMMON / D / NOAV, NQMAX
      REAL NQAV, NQMAX, KABA
      CW0 = 03
      CW1 = D4
      D5 = KABA + CW0 * D1 + CW1 * D2 + EEITA * NQMAX + ZITA* NQAV
      D6 = KABA = CW0 * D1 + CW1 * D2 + (EEITA + ZITA) * NQAV
      WHRITE (3,5) D5, D6, D1, D2
      5 FORMAT (2X, ' TOTAL COST WITH NPEAD AND NAVERAGE = ', 2E12.5
     * ,/,2X, ' LAYERS THICKNESSES AS BASIS OF COST CAL.= ', 2EQW.5)
      RETURN
      END
```

```
    4 Y4 = (SQRT(V7)-V5)/2.
      DELOS = Y4
      DELIS = 1. Y4
      WRITE (3,5) DELOS, DELIS
    5 FORMAT (2X, ' OPT. LO = ', E12.5, /, 2X, ' OPT LI
      1 = ', EQW.5)
      XO = Y4 * XT
      XI = DELIS * XT
      WRITE (3,2) DELOS, DELIS
    2 FORMAT (2X, ' OPTIMOM OUTDOOR LAYER DO* = ', EQW.5,/,
    * 2X, ' OPTIMUM INDOOR LAYER DI* = ', E12.5)
      GO TO 10
    3 CONTINUE
      WRITE (3,7)
    7 FORMAT (2X, ' FAILURE')
   10 CONTINUE
   12 X0 = 0.0
      XI = LENGTH - X0
      RETURN
      END
```

```
      SUBROUTINE ECON (XT, XO, XI, J)
      COMMON/A/ HR, CON, THTAO, RIO, THTARD, RAN, TC0, TC1, LENGTH
      COMMON/B/ CW0, CW1, RW, RU, CIW0, CIW1, CD0, CD1, CU, LAMDAU
     * , CE, S, LOAD, TAMAX, TAMIN
      COMMON/C/EEITA, ZITA, KABA
      REAL KABA, LOAD, LAMDAU, LENGTH
      KABA = RW * (CIW0 + CIW1 + CD0 + CD1) + (CU * RU/LAMDAU + 8760. * ICE.
     * S)) * LOAD
      EEITA = CU * RU * HR * (TAMAX - TAMIN) / LAMDAU
      EEITA = EEITA * 0.0011628
      SITA = 8760 * HR * (TAMAX - TAMIN) * (CE + S)
      ZITA = ZITA * 0.0011628
      WRITE (3,14) EEIA, ZITA, KABA
   14 FORMAT (3E12.5)
      IF (J. EQ. 3) GO TO 12
      VO = CON * THTAP - CON * THTARO + TAN * RI0
      V1 = (EEITA + ZITA) * CON * VO / (LENGTH * RW * CW1))
      V2 = 1. + CON + BIN1 * CON
      V3 = CON (BIN0 BIN1)
      V4 = BIN1 = BIN0
      V5 = (2. * V2 * V3 - V1 * V4)/(V3 * V3)
      V6 = (V2 * V2 + V1/BIN0) / (V3 * V3)
      V7 = V5 * V5 - 4. * V6
      IF(V7) 3,4,4
```

```
      IF (SELECT, EQ. 1) GO TO 716
      IF (SELECT. EQ. 3) GO TO 716
      IF (SELECT. EQ. 4) GO TO 716
      IF (SELECT. EQ. 0) GO TO 716
      CALL EXPENS (THICO, THICI, CWO, CW1, EXPT, EXAV)
      JEC = JEC + 1
      WRITE (3,709) JEC
709  FORMAT (2X, ' ECONOMIC TEST JEC = 3 IS THE MAX. INCREASE LIMIT
      AND JEC GT. O IS THE DECREASE LIMIT JEC= '.(3)
      THICO = REF + LENGTH * RJEC/10
      RJEC = JEC
      IF (JEC. GT. 3) THICO = REF - LENGTH * RJEC/10.
      IF (JEC. EQ. 6) GO TO 710
      THICI = LENGTH - THICO
      GO TO 29
710  CONTINUE
716  GO TO 26
      END
```

```
      QT(1) = 0.0
      QR(1) = 0.0
      GU(1) = 0.0
      DO 90 KS = 1,23
      KJ = KS + 1
      QU(KJ) = QU(KS) + AQUS(KS)
      QT(KJ) = QT(KS) + SIT(KS)
      QR(KJ) = QR(KS) + SIR(KS)
   90 CONTINUE
      TOTAL = QU(24) + HST1
      QH(IT) = TOTAL
      WRITE (3,91) T, QT(24), QR(24), QU(24), TOTAL
   91 FORMAT (5312.5)
  717 CONTINUE
C  ************************************************************************
  100 CONTINUE
C  ************************************************************************
      NQAV = HST1
      NQMAX = AMAX1 (QH(2), QH(4), QH(6), QH(8), QH(10), QH(12),
     +  QH(14), QH(16), QH(18), QH(20), QH(22))
      WRITE (3,801) NQAV, NQMAX
  801 FORMAT (2X, ' AVERAGE AND MAX. FLUX = ',2E12.5)
  715 CONTINUE
  718 CONTINUE
```

```
0164          TSIN2 = T12/TT2
0165          TCOS2 = T22 / T22
0166      290 FSIN2 = SIN (FA12)
0167          FCOS2 = COS (FA12)
0168          IF (FSIN2 / TSIN2) 300, 300, 320
0169      320 IF (FCOS2 / TCOS2) 300, 300, 330
0170      330 CONTINUE
0171          FA12 = FA12
0172          GO TO 340
0173      300 FA12 = FA12 + 3.1415
0174          GO TO 290
0175      340 CONTINUE
0176          FIA = CABS(F1)
0177          F2A = CABS (F2)
0178          QT1 = FIA * TTA(IS) * COS(OMT + FA11)
             * + TTB(IS) * FIA * SIN (OMT + FA11)
0179          QR1 = F2A * (RRA(IS) * COS (OMT + FA12)
             * + RRB (IS) * SIN(OMT + FA12))
0180          QT1 = - QT1
0181          QR1 = -QR1
0182          AQUS(IS) = QT1 + QR1
0183          SIT(IS) = QT1
0184          SIR (IS) = QR1
0185       30 CONTINUE
```

```
      C TEST OF THE ANGLE FOR HARMONIC CASE
C ****************************************************************************
      TI = AIMAG(F1)
      T2 = REAL (F1)
      TTO = CABS (F1)
      TSIN = TI/TTO
      TCOS = T2/TTO
190   FSIN = SIN(FA11)
      FCOS = COS (FA11)
      IF (FSIN / TSIN) 200, 200, 220
220   IF (FCOS / TCOS) 200, 200, 230
230   CONTINUE
      FA11 = FA11
      GO TO 240
200   FA11 = FA11 + 3.1415
      GO TO 190
240   CONTINUE
      C TEST FOR THE SECOND LAYER
C ****************************************************************************
C
C
      T12 = AIMAG (F2)
      T22 = REAL (F2)
      TT2 = CABS (F2)
```

```
GI = PI * DELI
GO = PO * DELO
SHO = (CEXP (GO) - 1./(CEXP(GO))I I 2,
CHO = (CEXP(GO)+1./CEXP(GO)I/2.
SHI = (CEXPIGI)-I, /(CEXP(GI))I/2.0
CHI = (CEXP(GI) + 1./(CEXP(GI)I I/2.O
CI = PI * SHI * BINI * CHI
C2 = PI * CHI + BINI * SHI
CID = PO * CHO + BINO * CON * SHO
C2D = PO * SHO + BINO * CON * CHO
ALAM = SQRT(FOI/FOO)/RK
DM = - CI * CID - ALAM * C2 * C2D
FG = ALAM * BINO * CON
FI = FG * PI /DM
F2 = FI * RAN / CON
ZZZI = AIMAG (F1)
ZZZ2 = AIMAG (F2)
FI = REAL (F1)
R2 = REAL (F2)
PII = ZZZI / R1
R22 = ZZZ2 / R2
FALL = ATAN (R11)
FAI2 = ATAN (R22)
```

```
      S + ((1,0 + BINI * DELL) * BINO * CON) / RK
      AO = SI/S2
C ***************************************************************************
      S3 = ZITA * (1.0 + DELL * BINI) /RK
      S4 = BINI * THTARO *(1, + BINO * CON * DELD)
      B = (S3 + S4) / S2
      HST = AO/(BINI * RK)
      HSTI = AO * DELI /RK + B - THTARO
      IF (SELECT. EQ. 3) GO TO 719
      WRITE (3,3) AO, B, HST, HSTI
    3 FORMAT ('UNTEGRATION CONSTANTS AND STEADY STATE HEAT',/, 4E12.5)
      WRITE (3,100)
  100 FORMAT (' TIME          QT          QR          QU          TT')
  719 CONTINUE
      DO 110 IT = 2,26,2
      DO 30 IS = 1,23
      AS = IS
      T=IT
      T = T-2.0
      OM = 0.2617993 * AS
      OMT = 0.2617993 * AS * T
      ZA = OM * Z
      PO = CSQRT (ZA) / SQRT (FOO)
      PI = CSQRT (ZA) / SQRT (FOL)
```

```
S ALFAL ',/, 4F10.4, 2E12.5)
      WRITE (3,28) CON, BINO, BINI, NKO, NKI, FDO, FDI
   28 FORMAT ('         NH          BINO          BINI          NKO          NKI
      S FOO    FOI './, 7E12.5, ///)
      IF (SELECT. EQ. O) GO TO 29
      IF (SELECT. EQ. 1) GO TO 29
      IF (SELECT. EQ. 4) GO TO 29
      XT = THICO + THICI
      CALL ECON (XT, XOO, XOI, SELECT)
      IF (SELECT. EQ. 3) GO TO 29
      THICO = XOO
      THICI = XOI
      REF = THICO
      JEC = 0
   29 CONTINUE
      DELO = THICO/(THICO + THICI)
      CELI = THICI/(THICI + THICI)
      C    STEADY  STATE   TERM
C   ****************************************************************************************************
C
C
      ZITA = BINO * CON * THTAO * BINO * RAN * RIO
      SI = BINI * BINO * CON * THTARO - ZITA * BINI
      S2 = BINI *(1.0 * BINO * CON * DELO)
```

```
      IF (SELECT. EQ. 4) GO TO 42
      IF (SELECT. EQ. O) GO TO 41
      RT = THICI
      GO TO 42
   41 RT = THICO
   42 CONTINUE
      IF (SELECT. EQ. 3) GO TO712
      IF (SELECT. EQ. 2) GO TO 712
      TRT = THICO + THICI
      DO 715 L = 1,4
      DIV = L
      IF (SELECT. EQ. O) THICO=RT * DIV/4.0
      IF (SELECT. EQ.1) THICI = RT *DIV /4.
  712 CONTINUE
  720 CONTINUE
      RK = TCI/TCO
      BINO = HR *(THICO + THICI)/TCO
      BINI = BINO/RK
      NKO = ALFAD *HR *HR *24 / (TCO *TCO)
      NKI = VKO *ALFAL / IRK *RK *ALFAO)
      FOO = NKO /(BINO*BINO)
      FOI = NKI/I BINI *BINI)
      WPITE (3,2) THICO, THICI, TCO, TCI, ALFAD, ALFAL
    2FORMAT ('           LO           LI           KO           KL           ALFAD
```

```
      READ (1,707) LOAD, TAMAX, TAMIN
707  FORMAT (3F10.4
708  FORMAT (2X, 'LOAD KW/M2                                    =',F10.4,/,
   *  2X, ' MAX. AND MIN. AIR TEMP C                          = ', 2F10.4)
C ********************************************************************************
      READ (1,700) CWD, CW1, CIWO, CIWI, CDO, CDI
 26  READ (1,14) THICO, THICI, TCO, TCI, ALFAD, ALFAL
 14  FORMAT (4F10.4), 2E12.5)
      READ (1,714)
      WRITE (3,714)
714  FORMAT ('
      READ (1,40) SELECT
 40  FORMAT (2X,12)
      WRITE (3,43) SELECT
 43  FORMAT ('THIS CASE IS FOR OPTION SELECT= ',12)
      WRITE (3,701) CWO, CW1, CIQO, CIWI, CDO, CDI
700  FORMAT (6F10,4)
701  FORMAT (2X,' WALL INITIAL COS LD/M2=',2F10.4,/,
   1  2X, 'WALLS INSTALLATION COST LD/M2 LD/M2', 2F10.4,/,
   2  2X, 'WALLS DECORATION COSTS LD/M2= ', 2F10.41
      WRITE (3,703) RW, RU, LAMDAU
      WRITE (3,705) CU, CE,S
      WRITE (3,708) LOAD, TAMAX, TAMIN
C ********************************************************************************
      IF (SELECT. EQ. 3) GO TO 720
```

```
      ARIA (II) = RIA
      ATHTAA (II) = THTAA
   25 CONTINUE
      THTARA = 0.0
      DO 27 KI = 1,23
      RPA(K1) = ARIA(K1)
      RRB(K1) = ATHTAA(K1)
      K2 = K1 + 23
      TTA(K1) = ARIA(K2)
      TTB(K1) = ATHTAA (K2)
      WRITE (3,22) RRA(K1), RRB(K1), TTA(K1), TTB(K1)
   22 FORMAT (2X, 4F10.7)
   27 CONTINUE
C ****************************************************************************************
      READ (1,702) RW, RU, LAMDAU
      READ (1,704) CU, CE, S
  702 FORMAT (3F10.4)
  703 FORMAT (2X,' FIXED CHARGES RATE OF WALL%='F10.4,
      1/ ,2X, 'FIXED CHARGES RATE OF UNIT%              ='           ,F10.4,
      2/,'UNIT UTILIZATION FACTOR                                 =',F10.4)
  704 FORMAT (3F10.4)
  705 FORMAT (2X,' UNIT COST LD/KW-M2 INSTALLED = ',F10.4,/,
      1 2X, 'ELECTRICITY RATE LD/KWH M2                          =', F10.4,/.
      2 2X, ' MAINTENANCE RATE LD/KWH M2 = ', F10.4)
```

```
0001          DIMENSION ARIA(50), ATHTAA (50), AQUS(50), QU(50), SIT(50),
              SIR(50), QT(50), QR(50),
             * RRA(30), RRB(30), TTA(30), TTB(30), QH(50)
0002          PEAL NKO, NKL
0003          REAL LOAD, LENGTH, LAMDAU, NQMAX, NQAV
0004          INTEGER SELECT
0005          COMPLEX PL, Z/(0.0, 1.0)/, G0, G1, ZA, P0,
             * SHI, CHI, SHO, CHO, C1, C2, C1D, C2D,
             * F1, DM, F2
0006          COMMON/A/ HR, CON, THRAO, RIO, THRARO, RAN, TCO, TCI, LENGTH
0007          COMMON/B/ CWO, CWI, RW, RU, CIWO, CIWI, CDO, CDI, CU, LAMDAU
               , CE, S, LOAD, TAMAX, TAMIN
0008          COMMON/D/ NQAV, NQMAX
0009          READ (1,16) HR, THICL
0010       16 FORMAT (2F10.4)
0011        5 READ (1,10) CON, BIN, RAN, ALFA
0012          READ (1,15) RIO, THTAO, THTARO,
0013       10 FORMAT (4F10.4)
0014       15 FORMAT (3F10.4)
0015          WP TE (3,6) HR, RAN, RIO, THTAO, THTARO
0016        6 FORMAT (2X, ' HR, NI, RIO, TAO, TRO = ', 5F10.4)
0017          DO 25 II=1, 46
0018          READ (1,20) RIA, THTAA
0019       20 FORMAT (F10.7, 2X, F10.7)
```

CARD Q (4F 10.4, 2E12.5)

THICO	l_0 The thickness of the first layer	m
THICI	l_1 The thickness of the second layer	m
TCO	k_0 Thermal conductivity of the first layer	kcal/m h c
TCI	k_1 Thermal conductivity of the indoor wall layer	kcal/m h c
ALFAO	α Thermal diffusivity of outdoor layer	m2/h
ALFAL	α_1 Thermal diffusivity of indoor layer	m2/h

CARD No. 10 ('.....')

'...'	This card is for users to write any remark, these remarks is within 60 letters, and will be printed out such as THIS CASE IS FOR CONCRETE AND GYPSUM

CARD No. 11 (2X, I2)

SELECT	Optional, SELECT – O the outdoor layer will be divided into 4 equal parts and the heat flux is calculated for each case. SELECT–1 Same as above but for the indoor layer. SELECT – 3 No division of layers and the cost C_T is calculated and printed out using average and max, heat fluxes. SELECT-4 Calculating the optimum wall thicknesses through SUBROUTINE EXPENS. Th3.

N.B. The algrithm of the subroutine EXPENS is different than that presented in the texte.

CARD No. 5 (3F 10.4)

RW	Annual fixed charges rate for wall	
RU	Annual fixed charges rate for refrigeration units	
LAMDAU	Capacity factor for the refrigeration units	

CARD No. 6 (3F 10.4)

CU	Unit capital cost	D/kW
CE	Electricity rate	D/kWh
s	Maintenance rate	D/kWh

CARD No. 7 (3F 10.4)

LOAD	Internal building load	kW
TAMAX	Maximum outdoor air temp.	C
TAMIN	Minimum outdoor air temp.	C

CARD No. 8 (6F 10.4)

CWO	Specific outdoor layer cost	D/m^3
CWL	Specific indoor layer cost	
CIWO	Installation cost for the outdoor layer	D/m^2
CIWL	Installation cost for the indoor layer	D/m^2
CDO	Cost for decoration, outdoor layer	D/m^2
CDL	Cost for decoration, indoor layer	D/m^2

N.B. The cost of installation and/or decoration are set zeros if they are included in the specific costs. (See page 58)

CARD 2 (4 F 10.4)

CON	N_h Convection ratio h_o/h_r
BIN	N_{Bl} Biot Number for the case of one layer wall
RAN	N_I Radiation ratio $\dfrac{I_{max}}{h_r(t_{a,max} - t_{a,min})}$
ALFA	α Thermal diffusivity for the case of one layer wall m2/h

N.B For two layers wall BIN and ALFA take the values for the first layer (0)

CARD 3 (3 F 10.4)

RIO	$R_{I,o}$ the first term of the Fourier series for the incident heat flux
THTAO	$\theta_{a,o}$ the first term of the Fourier series for the convective heat flux
THTARO	$\theta_{r,o}$ The dimensionless room temperature $O_{r,o} = (t_r - t_{a\ min}) / (t_{a,max} - t_{a,min})$

CARD 4 (F 10.7, 2X, F 10.7)

RIA	The constants for the radiant heat flux 23 terms series $a_i \cos w_i r + b_i \sin w_i r$. R_{IA} are a_1, a_2..... a_{23}, b_1, b_2,..... b_{23}.
THTA	The constants for the temperature heat flux, 23 terms series. $c_i \cos w_i r + d_i \sin w_i r$. THTA is array of 46 terms c_1, c_2.... c_{23}, d_1, d_2,....... d_{23}

N.B. Card 4 is a 46 cards each card has two values for a_i and c_i to b_{23} and d_{23}

COMPUTER PROGRAM

The computer program is written in FORTRAN IV for the IBM 370 computer. The following items are covered in the program attached,

1 – READ, check and edit the input data
2 – Calculate the steady state heat flux, and check
3 – Calculate and check the harmonic parts of the heat flux for n=1 to 23
4 – Optimum thickness of wall layers for two layers wall, with a procedure given in subroutine EXPENS,

N.B. The theoretical analysis given in chapter 3 is a general one but the present code is written for two layers wall with the distance = 0 at the layers interface.

Description of the input cards is given in the following.

COMPUTER CODE USERS MANUAL:

The computer code is made in a master program form. The code operates according to the following flow of computation.

1 – Read, check and edit the input data.
2 – Calculation of the steadystate heat flux. N_{qav}. Check.
3 – Calculate and check the harmonic parts of the heat flux for n=1-23
4 – Calculate; $N_{qav} + \sum_{1}^{24} N_q(2n\pi t)$
5 – Optimum Economic Calcutations.

INPUT DATA CARDS

CARDS 1 (2 F 10.4)		
HR	h_r Room heat transfer coefficient	kcal /m2 h C
THICL	The maximum limit for the wall $(l_1 + l_2)$	m.

APPENDIX B
COMPUTER PROGRAM

OUTSIDE AIR REDUCED TEMPERATURE AND ITS FOURIER SERIES FACTORS

n=k-1	τ	a	a,c,n	a,s,n
0	5 am	0.00	0.5310417	0.00
1	6	0.147	-0.1924190	0.1321887
2	7	0.313	-0.0290246	-0.0138200
3	8	0.465	-0.0207577	0.0044517
4	9	0.610	-0.0061875	0.0011186
5	10	0.728	-0.0069731	0.0005496
6	11	0.838	-0.0028750	0.0015000
7	12 N	0.919	-0.0017150	0.0005171
8	1 pm	0.976	-0.0012709	0.0007578
9	2	0.997	-0.0010761	-0.0007983
10	3	1.00	-0.0016005	-0.0001801
11	4	0.961	-0.0013097	-0.0007788
12	5	0.897	-0.0006250	0.0
13	6	0.796	-0.0013097	0.0007788
14	7	0.667	-0.0016005	0.0001801
15	8	0.556	-0.0010761	0.0007983
16	9	0.467	-0.0012709	-0.0007578
17	10	0.392	-0.0017150	-0.0005171
18	11	0.327	-0.0028750	-0.0015000
19	12 mn	0.258	-0.0069731	-0.0005496
20	1 am	0.198	-0.0061875	-0.0011186
21	2	0.148	-0.0207573	-0.0044517
22	3	0.072	-0.0290246	0.0138200
23	4	0.012	-0.1924190	-0.1321887

RELATIVE INSOLATION ON EAST WALLS AND ITS FOURIER SERIES FACTORS

n=k-1	τ	M_I	$R_{I.c.n}$	$M_{I.s.n}$
0	5 am	0.00	0.22408	
1	6	0.696	0.0583295	0.1756665
2	7	0.974	-0.0758324	0.0986072
3	8	1.00	-0.0831638	-0.0047481
4	9	0.904	-0.0218750	-0.0268468
6	11	0.435	-0.0152500	-0.0172500
7	12 N	0.130	0.0030635	-0.0222032
8	1 pm	0.122	0.0069585	-0.0082376
9	2	0.109	0.0041638	-0.0077461
10	3	0.096	0.0093824	-0.0093572
11	4	0.078	0.0109689	-0.0006342
12	5	0.065	0.0077500	0.0
13	6	0.039	0.0109889	0.0006342
14	7	0.00	0.0093824	0.0093572
15	8	0.00	0.0041638	0.0077461
16	9	0.00	0.0069983	0.0092376
17	10	0.00	0.0030835	0.0222032
18	11	0.00	-00152500	0.0172500
19	12 MN	0.00	-0.0128620	0.0110039
20	1 am	0.00	-0.0218750	0.0268468
21	2	0.00	-0.0831638	0.0047481
22	3	0.00	-0.0756324	-0.0986072
23	4	0.00	0.0583295	-0.1736665

RELATIVE INSOLATION ON ROOFS AND SOUTH WALLS AND ITS FOURIER SERIES FACTORS

n=k-1	τ	R_1	$R_{1,c,n}$	$R_{1,s,n}$
0	5 am	0.00	0.311808	
1	6	0.0551	-0.0633550	0.2364439
2	7	0.2331	-0.091236	-0.0529560
3	8	0.4619	0.0043617	-0043617
4	9	0.6780	-0.0075917	-0.0131492
5	10	0.8517	0.0009617	-0.0002577
6	11	0.9619	0.0	-0.0045917
7	12 N	1.00	-0.0001079	-0.0000289
8	1 pm	0.9619	0.0008833	-0.0015300
9	2	0.8517	-0.0001284	-0.0001284
10	3	0.6780	0.0006236	-0.0003600
11	4	0.4619	-0.0000071	-0.0000265
12	5	0.2331	0.0003583	0.0
13	6	0.0551	-0.000071	0.0000265
14	7	0.0	0.0000230	0.0003600
15	8	0.0	-0.0001284	0.0001284
16	9	0.0	0.0008833	0.0015300
17	10	0.0	-0.0001079	0.000289
18	11	0.0	0.0	0.0045917
19	12 mn	0.0	0.009617	0.0002577
20	1 am	0.0	-0.0075917	0.0131492
21	2	0.0	0.0043617	0.0043617
23	3	0.0	-0.0917236	0.0529566
24	4	0.0	-0.0633550	-0.2364439

APPENDIX A

REDUCED AVERAGE METEOROLOGICAL DATA
FOR
SUMMER MONTHS

THERMAL BEHAVIOUR OF BUILDINGS

ITS DETERMINATION AND ECONOMICS

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APPENDICES

max	maximum
min	minimum
o	outside surface
q	heat flux
r	room
	running cost
sin	sine
U	refrigeration/air conditioning unit
T	total
w	wall or building component
	temperature

P	real part (Chapter 2)
	period of operation (Chapter 4), h/y
P	total power, kW
p	defined by eqn (2.20)
Q	imaginary part (Chapter 2)
	total flux (Chapter 4), W
q	flux density, W/m^2
	Ratio
r	modulus of function F
S	defined by eqn (1.21)
S	defined by eqn (3.33)
s	Laplace variable
T	dimensionless time
T	defined by eqn (3.34)
t	temperature, K
X	dimensionless distance
x	coordinate distance, m
w	room water equivalent, J/K
Z	Lagrange multiplier
α	thermal diffusivity, m^2/s
γ	defined by eqn (2.29)
ϵ	emissivity, dimensionless
θ	reduced temperature
λ	utilization factor, dimensionless
	density, kg/m^3
τ	time, s
ϕ	argument of function F
ψ	time lag, rad.

SUPERSCRIPTS

—	vector (Chapter 1)
	Laplace transformed function (Chapters 2 and 3) total (Chapters 4 and 5)
*	optimum
«	per unit area

SUBSCRIPTS

a	outside air
av	average
B	building
C	cooling
c	conductive
cos	cosine
cy	cycle
e	electric energy
H	heating
I	Insolation
	building component
i	internal
	inside surface
j	general layer number
M	model

NOMENCLATURE

SYMBOLS

A	surface area, m^2
	integration constant, dimensionless
$\mathcal{A}$	defined by eqn (4.8)
α	defined on p. 58 31
a	defined on p. 74
B	integration constant, dimensionless
	defined by eqn (4.7)
b	defined on p. 58
C	annual cost, D/m^2 y
c	specific heat, J/kg K
	unit cost
C	total cost per unit area, D/m^2
	defined by eqn (4.11)
E	total annual energy
F	defined by eqn (2.21)
F	annual fixed charge rate, y^{-1}
Θ	defined by eqn (4.14)
H	transfer function
h	heat transfer coefficient, W/m^2 K
I	insolation, W/m^2
i	imaginary unit
K	constant of proportionality
K	defined by eqn (3.29)
k	thermal conductivity, W/m K
L	reference length, m
L	defined by eqn (3.30)
l	length,m
M	integer
M	defined by eqn (3.31)
m	number of wall layers
N	dimensionless group
	dimensionless unit normal
N	defined by eqn (3.32)
n	integer, 1,2,3,...
	unit normal

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However, the question is: To what extent would neglecting the peak load affect the optimization process? In other words; would the inclusion of q_p shift the optimum wall dimensions to an extent that would considerably change the total annual cost? These questions are answered in the present case by the uppermost curve in Fig 5.1 where the term O q_p of eqn (4.7) is included in the total annual cost represented by this uppermost curve. This curve gives an optimum concrete slab thickness $l^*_1=0.12$ m which is quite different from the value obtained earlier through the use of eqn (4.13). However, the curve being flat in this region of optimality, the new dimensions affect the total annual cost by a very small amount as could be seen from the following table

Optimum value obtained from		eqn (4.7)	eqn (4.13)
l^*_1	m	0.12	0.17
q_{max}	W/m2	24.799	29.762
q_{av}	W/m2	16.156	19.078
C_w	D/m2y	4.695	4.057
C_L	D/m2y	2.480	2.976
C_r	D/m2y	1.415	1.671
C_T	D/m2y	8.590	8.704

The difference between the two values of the total annual cost as given in the table is about 1.3 percent which is negligible. Indeed, this percentage would be even much less if the internal load is taken into consideration. It may be concluded, therefore, that the procedure recommended in Section 4.7 is ample for optimization.

5.6 CONCLUSIONS

In this chapter, an example of optimizing the wall, machinery and energy consumption for a cold store is solved. The example is purposely simple to lucidate the optimization procedure. It is shown that the simplified procedure suggested in Chapter 4 is, indeed, ample in this case.

Calculations showed that q_p = 10.7 W/m2. Therefore, the total conductive flux density = 30.8 W/m2. The total conductive flux is, therefore

$$Q_c = 30.8 \times 765 / 1000 \cong 23.6 \quad \text{kW}$$

The refrigeration unit must meet this conductive load plus the internal load specified (Q_i = 100kW)I; this adds up to a maximum load of 123.6 kW. With the specified utilization factor λ_U=0.85, the unit capacity should be

$$P = 123.6 / 0.85 \cong 145 \quad \text{kW}$$

The total unit cost is, therefore

$$\bar{C}_U = 145 \times 425 = 61625 \quad \text{D}$$

5.4.3 OPERATING COST

This is an annual cost and could be calculated from eqn (4.5) as

$$C_r = 8760\ c_e\ q_{av}$$
$$= 8760 \times 0.01 \times 19.08 / 1000 = 1.671 \quad \text{D/m}^2\ \text{y}$$

For the whole wall area, the operating cost is

$$\bar{C}_r = 1.671 \times 765 \cong 1280 \quad \text{D/y}$$

5.4.4 OVERALL ANNUAL COST

The overall annual cost for this wall, refrigeration unit, and electric consumption is given by

$$\bar{C}_T = F_w \bar{C}_w + F_U\ \bar{C}_U + \bar{C}_r$$
$$= 0.15 \times 20695 + 0.2 \times 61625 + 1280 \quad \text{D/y}$$
$$\cong 16710$$

5.5 EFFECT OF PEAK LOAD

The value calculated above should be compared with that calculated without the internal or peak loads, namely

$$C_T = 7.64 \times 765 \cong 5845 \quad \text{D/y}$$

The sizable difference of 10865 D/y is due to the extra cost of equipment to cover the peak and internal loads, the latter is quite large. Even if the internal load is nil, the difference would still be about 1100 D/y which is still considerable.

$$\text{Therefore, } l^*_1 = (k_1 / h_0)(h_o\, l^*_1 / k_1) = (1.4/15)(h_o\, l^*_1 / k_1)$$

$$= 0.725 \text{ m} \quad \text{or} \quad 0.1678 \text{ m}$$

For the present case to have l^*_1 within 0.3 m choose

$l^*_1 = 0.1678$ m = 17cm of concrete slab

Therefore l^*_2 = 13cm of lightweight concrete

This value of l^*_2 could also be obtained from eqn (4.26)

5.3.4 MEANING OF SOLUTION

The meaning of this solution could be explained from the basic relations which are shown graphically in Fig. 5.1. In this figure the annual costs are calculated for various thicknesses of the wall layers. It shows the annual cost C_w of the wall as calculated from wqns (4.1 and 2); that of the unit, C_U, is calculated from eqn (4.4); of energy consumption, C_r from eqn (4.5); and their sum, the total annual cost C_T. To calculate C_U and C_r, the average heat flux is calculated from eqn (3.48).

Whereas C_w decreases monotonely as l_1 increases, C_U and C_r increase monotonely with the increase in q_{av}. This results in C_T having a minimum value at l_1 = 16.78 cm as calculated.

5.4 CALCULATIONS OF COSTS

For the optimum wall with l_1= 17 cm and l_2 =13 cm, the costs are as follows

5.4.1 WALL COST

This could be obtained from eqn (4.1) for a unit wall area as

$$C_w = \quad + a_1 + a_2 + b_1 l_1 + b_2\, l_2$$

$$= 3 + 1.5 + 4 + (25 \times 0.17) + (110 \times 0.13)$$

$$= 27.050 \qquad \text{D/m}^2$$

The total cost of the whole wall of area 765 m2 is

$$\overline{C_w} = 27.050 \times 765 \qquad 20695 \quad \text{D}$$

5.4.2 REFRIGERATION UNIT COST

The average heat flux is calculated from eqn (3.38) as

$$q_{av} = h_r \quad t\,[R_h\,(\Theta_a - \Theta_r) + N_1\, R_{I,av}] /$$

$$[\,1 + R_h + (h_o\, l_1 / k_1) + (h_o\, l_2/k_2)]$$

$$= \frac{5 \times 15\,[3(0.531 - 0) + (6 \times 0.312)]}{1 + 3 + 15\,[(0.17/1.4) + (0.13/0.25)]}$$

$$= 19.08 \qquad \text{W/m}^2$$

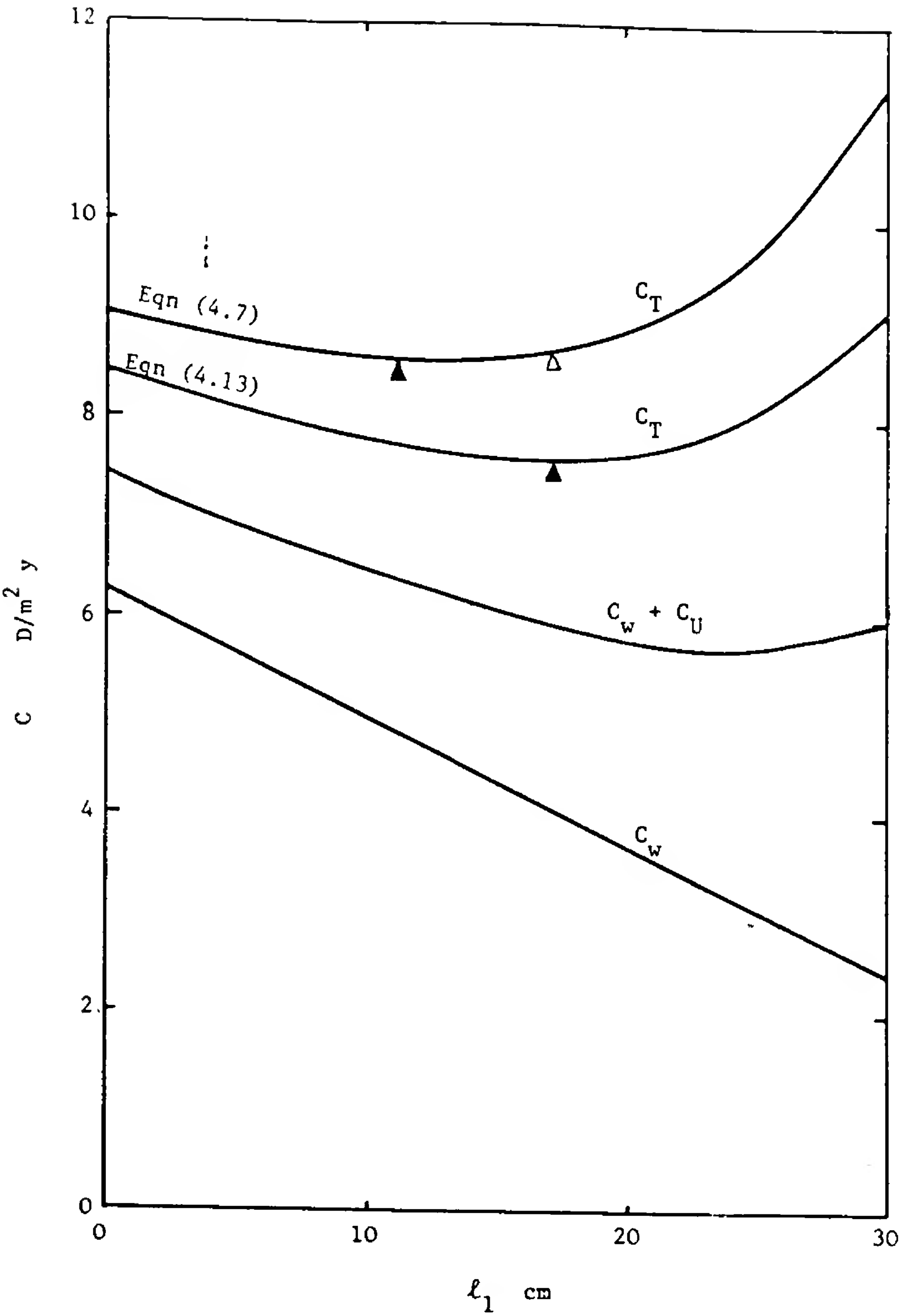


Fig 5.1

Refrigeration system overall cost $c_U = 425$ D/kW

Energy cost $c_e = 0.01$ D/kW h

Fixed charge rates

For buildings $F_w = 15\%$

For machinery $F_U = 20\%$

Utilization factor for refrigeration equipment $\lambda_U = 85\%$

5.3.3 CALCULATIONS

The thermal resistance of the covering paints and plaster will be neglected. Further, the term O q_p in eqn (4.7) is also neglected; its effect is checked at the end of the calculations. The present is a general case of a two-layer component where eqns (4.25 and 26) should be used. The variables used in these equations are

$$A = F_w(\alpha + a_1 + a_2) \tag{4.8}$$

$$= 0.15\ (3 + 1.5 + 4) = 1.275 \quad \text{D/m2 y}$$

$$b_1 = b_1/A = 25/\ 1.275 = 19.608 \quad \text{y/m}$$

$$b_2 = b_2/A = 110/1.275 = 86.275 \quad \text{y/m}$$

$$B = [(F_U\, c_U/\ \lambda_U) + 8760\, c_e] / A \tag{4.10}$$

$$= [(0.2 \times 425\ /\ 0.85) + 8760 \times 0.01]\ /\ 1.275$$

$$= 147.137 \quad \text{m2/kW}$$

$$= 0.147137 \quad \text{m2/W}$$

$$G = B\, h_r \quad \Delta t\, [R_h(\Theta_{a,av} - \Theta_r) + N_1 R_{1,av}] \tag{4.14}$$

$$= 0.147137 \times 5 \times 15\ [3(0.531 - 0) + 6 \times 0.312]$$

$$= 38.237$$

For calculations, eqn (4.25) is used; it gives

$$h_o\, l^*_1\ /\ k_1 = \sqrt{G h_o\, k_2\ /\ F_w\, k_1\, (b_1 - b_2)\,(k_2 - k_1)}$$

$$+\ k_2\ [R_h + (h_o\, L\ /k_2) + 1]/\ (k_1 - k_2)$$

$$= \sqrt{\frac{38.237 \times 15 \times 0.25}{0.15 \times 1.4\ (19.608 - 86.275)(0.25 - 1.4)}}$$

$$+\ [0.25/\ (1.4 - 0.25)]\ \left\{ 3 + [(15 \times 0.3)\ /\ 0.25] + 1 \right\}$$

$$h_o\, l^*_1\ /\ k_1 = \quad 2.9843 + 4.7826$$

$$= 7.7669 \quad \text{or} \quad 1.7983$$

5.3 SOLUTION

To determine the optimum dimensions of the above wall, the various parameters should be determined either from tables, experience and existing conditions of prices, finance rates, etc. or any other available source. The following values were thus obtained.

5.3.1 DESIGN CONDITIONS

$$\Delta t = t_{a,\ max} - t_{a,\ min} = 20-5 = 15$$

$$\Theta_r = (t_r - t_{a,min})/\Delta t = 0$$

Heat transfer foefficients

Indoors $h_r = 5$ W/m2

Outdoors $h_o = 15$ W/m2

Therefore $R_h = 3$

Insolation parameter, from eqn (1.9)

$$N_I = \epsilon\ I_{max} / h_r\ \Delta t$$

$$= 0.75 \times 600 / (5 \times 15) = 6$$

Assuming the values of Appendix A are applicable throughout the year, the average reduced air temperature, $\Theta_{a,c,o}$ in Table A.1

$$\Theta_{a,av} = 0.531$$

Average relative insolation, $R_{I,c,o}$ in Table A.2

$$R_{I,av} = 0.312$$

Thermal conductivies of wall materials, from Appendix C.

Concrete slab $k_1 = 1.4$ W/m K

Lightweight concrete blocks $k_2 = 0.25$ W/m K

5.3.2 PRICES AND FINANCING

General expenses including paint, etc. $\alpha = 3$ D/m2

Concrete slab installation and price $a_1 = 1.5$ D/m2

$b_1 = 25$ D/m3

Lightweight concrete block installation and price

$a_2 = 4$ D/m2

$b_2 = 110$ D/m2

5.1 INTRODUCTION

The analysis of Chapter 4 is put to work in an example in this chapter; it is a simple one to focus on the principles of economic analysis. Naturally, before such an analysis, the various loads other than those to be optimized have to be determined by methods adequately described in refrigeration and air conditioning literature. Of particular interest here are those of ASHRAE [1], IHVE [2] and the many text books available of which Threlkeld's [3] is of general nature and many others, of which Harris and Conde [22] is an example, are rather specific.

The load analysis starts by fixing the outside design conditions of location: dry– and wet-bulb temperatures, etc. The inside design conditions should also be determined; they include also dry–and wet-bulb temperatures, occupancy, internal electric load, type and orientations of doors and windows, type of activity, etc.

When the above conditions are determined, further loads are calculated such as ventilation, infilteration, etc. All the above loads, which exclude those through the building components to be optimized, are added for use in the analysis as described hereafter.

5.2 STATEMENT OF PROBLEM

It is required to calculate the optimum thickness and costs for the single exposed wall of a cold store in the northern hemisphere with the following design conditions given as annual mean values

Outside maximum dry-bulb temperature	20°C
Outside minimum dry-bulb temperature	5°C
Maximum outside solar intensity	600 W/m²
Inside dry-bulb temperature	5°C

The south facade of area 765 m² has no windows and is exposed to the atmosphere. All other walls, ceiling and floor are surounded by refrigerated spaces at the same temperature as the one considered and use separate refrigeration units. The total load due to the cold store contents (vegetables, etc.) was estimated at 100 kW and is practically constant.

The exposed wall is to be built of precast concrete slabs and insulated on the inside by lightweight concrete blocks. The outside wall surface is to be treated with a paint of emissivity 0.75, and the total wall thickness should be 30 cm.

Chapter 5

ECONOMICS EXAMPLE

4.8 CONCLUSIONS

The economic problem of optimizing the total cost of a building component, refrigeration/air conditioning unit and energy consumption was discussed in this chapter. The various costs are analyzed, divided into groups and their total optimized. A simplified optimization procedure is suggested whereby computer calculations would be reduced to a minimum.

4.7.1 SELECTION PROCEDURE

With all the factors discussed above in mind, the following procedure for the economic selection of the components of a given building is recommended for most cases

1 — Determine all loads other than those to be optimized as functions of time. Those could be lumped as Q_i kW.

2 — Decide on the constructions and materials to be used for each of the components to be optimized.

3 — Calculate the optimum dimensions using eqn (4.13).

4 — Using the method described in Chapters 2 and 3, determine the time variation of the flux density for the components optimized above.

5 — Multiply each of the flux densities thus determined by their respective areas and add to obtain the time variation of the total conductive load Q_c.

6 — Determine the time variation of $Q = Q_c + Q_i$, from which calculate Q_{av} and Q_p.

4.7.2 COSTS CALCULATIONS

It is recommended to determine the various costs as follows:

1 — Calculate the equipment size P from

$$P = Q_{max} / \lambda_U$$

$$= \left[(Q_{av} + Q_p)_i + \sum (q^*_{av} + q^*_p)_I A_I \right] / \lambda_L \qquad (4.27)$$

Here A_I is the surface area of component I.

2 — Calculate the total annual energy consumption E from

$$E = 8760\ Q_{av}$$

$$= 8760 \left[Q_{av,i} + \sum q^*_{av,I} A_I \right] \qquad (4.28)$$

3 — Calculate the components cost $\bar{C}_w$ from eqn (4.1)as

$$\bar{C}_w = \sum_I \left[\alpha + \sum_{J=1}^{M} (a_j + b_j l^*_j) \right]_I A_I \qquad \text{D} \qquad (4.29)$$

4 — Calculate the air conditioning unit cost $\bar{C}_U$ from eqn (4.3) as

$$\bar{C}_U = c_U P \qquad \text{D} \qquad (4.30)$$

5 — Determine the total annual operating cost as

$$\bar{C}_r = c_e E \qquad \text{D/y} \qquad (4.31)$$

6 — The overall annual cost is calculated from

$$\bar{C}_T = F_w \bar{C}_w + F_U \bar{C}_U + \bar{C}_r \qquad (4.32)$$

$$\frac{\partial (L.E)}{\partial l_1} = F_w b_1 - \frac{G\, h_o / k_1}{\left[\, 1+R_h + (h_o l^*{}_1/k_1) + (h_o l^*{}_2/k_2) \,\right]^2} + Z = 0 \qquad (4.22)$$

$$\frac{\partial (L.E)}{\partial l_2} = F_w b_2 - \frac{G\, h_o \,/\, k_2}{\left[\, 1+R_h + (h_o l^*{}_1/k_1) + (h_o l^*{}_2/k_2) \,\right]^2} + Z = o \qquad (4.23)$$

$$\frac{\partial (L.E)}{\partial Z} = l^*{}_1 + l^*{}_2 - L = 0 \qquad (4.24)$$

Subtracting eqn (4.23) from eqn (4.22) and substituting from eqn (4.24) gives

$$\frac{h_o\, l^*{}_1}{k_1} = \sqrt{\frac{G h_o\, k_2}{F_w k_1\, (b_1 - b_2)(k_2 - k_1)}} + \frac{k_2}{k_1 - k_2}\left(R_h + \frac{h_o L}{k_2} + 1 \right) \qquad (4.25)$$

In the above two equations, the radical would be imaginary if *either* $b_2 > b_1$ *or* $k_1 > k_2$. Such would be a case where the better insulator is cheaper and there would be no need, economically, to use the more expensive bad insulator. Conceivably, there are situations where such a material must be used because of other special properties. In a situation of this sort, the least thickness that could be used should be installed.

Further, the radical may yield a positive value or a negative one. Either should be used to satisfy the constraints, or to merely have a positive layer thickness.

It should be possible to extend the above procedure without much difficulty to more than two layers. However, it should be born in mind that the above derivations, eqn (4.13) and the following ones, are only for the cases where neglecting the term O_{qp} of eqn (4.7) would not affect the final result appreciably, which seems to be true in most cases.

4.7 SELECTION PROCEDURE AND EQUIPMENT SIZING

In the previous parts of this chapter, the economic discussion was restricted to a unit area of a single building component: a roof, a wall of certain orientation, etc. A building is, of course, a multi-component structure that have windows, doors, etc., together with the main structural components. However; important as the windows, skylights, etc. are as energy transmitting areas, they are not considered in the present analysis and may be optimized separately. Their effect should be included in, say, the internal load q_i which does not enter the optimization process but may considerably affect the final cost.

Further, the value of q_p is in some cases as large as q_{av}. This affects the total cost considerably although, in most cases, its effect on the economic choice is negligible. This is due to the fact that the ratio $N_{q,max}/N_{q,av}$ varies only slightly for most building materials combinations as could be seen from the tables of Appendix.

for $R_h + h_o \sum (L_k/k_k)=5$. Two sets of curves are drawn for the fixed charge rate parameter $F_w\, b\, k \,/\, h_o = 0.2$ and 0.6. The loci of the optimum conditions are also shown; they are straight lines. As expected and could be seen from the figure, the higher the value of the fixed charge rate parameter, the thicker the optimum layer is, and the more expensive it becomes. The curves within a set differ in the value of the cost parameter G which has the same effect on the total annual cost and optimum thickness as the fixed charge rate parameter.

Relation (4.17) is satisfied for some cases where $F_w\, b\, k \,/\, h_o = 0.6$; it shows that the minimum feasible component thickness should be used if $G \leq 21.6$.

4.6.3 GENERAL TWO-LAYER COMPONENTS

This is the case where the two layers are to be optimized. In this case, eqn (4.16) gives

$$\frac{h_o l^*_1}{k_1} = \sqrt{\frac{G h_o}{F_w\, k_1\, b_1}} - \frac{h_o l^*_2}{k_2} - R_h - 1$$

$$\frac{h_o\, l^*_2}{k_2} = \sqrt{\frac{G h_o}{F_w\, k_2\, b_2}} - \frac{h_o\, l^*_1}{k_1} - R_h - 1$$

A direct solution of the above two equations gives the trivial condition $k_1\, b_1 = k_2\, b_2$ which means that the cost per unit volume of the material should be inversely proportional to its thermal conductivity.

To solve such a case there should be a constraint and it would be more perspicuous to use the method of *Lagrange multipliers* [20]. This is carried out by developing Lagrange expression which consists of the objective function, in this case eqn (4.13), plus the products of Lagrangean multipliers and the constraints in the form of equations set equal to zero. Optimization is carried out in this method by differentiating partially this Lagrange expression with respect to the variables to be optimized and the Lagrange multipliers. The resulting expressions are equated to zero and solved simultanueously to obtain the optimum values.

In the present case, a hypothetical condition is set by fixing the overall thickness of the component as L. The constraint would thus be

$$l_1 + l_2 = L \tag{4.20}$$

Denoting Lagrange multiplier by Z, Lagrange expression would be, from eqns (4.13 and 20)

$$\text{L.E.} = 1 + F_w\,(b_1\, l_1 + b_2\, l_2) + \frac{G}{1 + R_h + h_o\left[\dfrac{l_1}{k_1} + \dfrac{l_2}{k_2}\right]}$$
$$+ Z(l_1 + l_2 - L) \qquad (421)$$

Partial differentiation gives

$$\frac{h_o l^*}{k} \quad \sqrt{\frac{Gh_o}{F_w k b}} - h_o \sum_k \frac{L_k}{k_k} - R_h - 1$$

Again, the L_k's may be large enough that the condition (4.17) would be satisfied and there would be no need for the extra layer.

This case is ilustrated in Fig. 4.1 which is a plot of eqn (4.13)

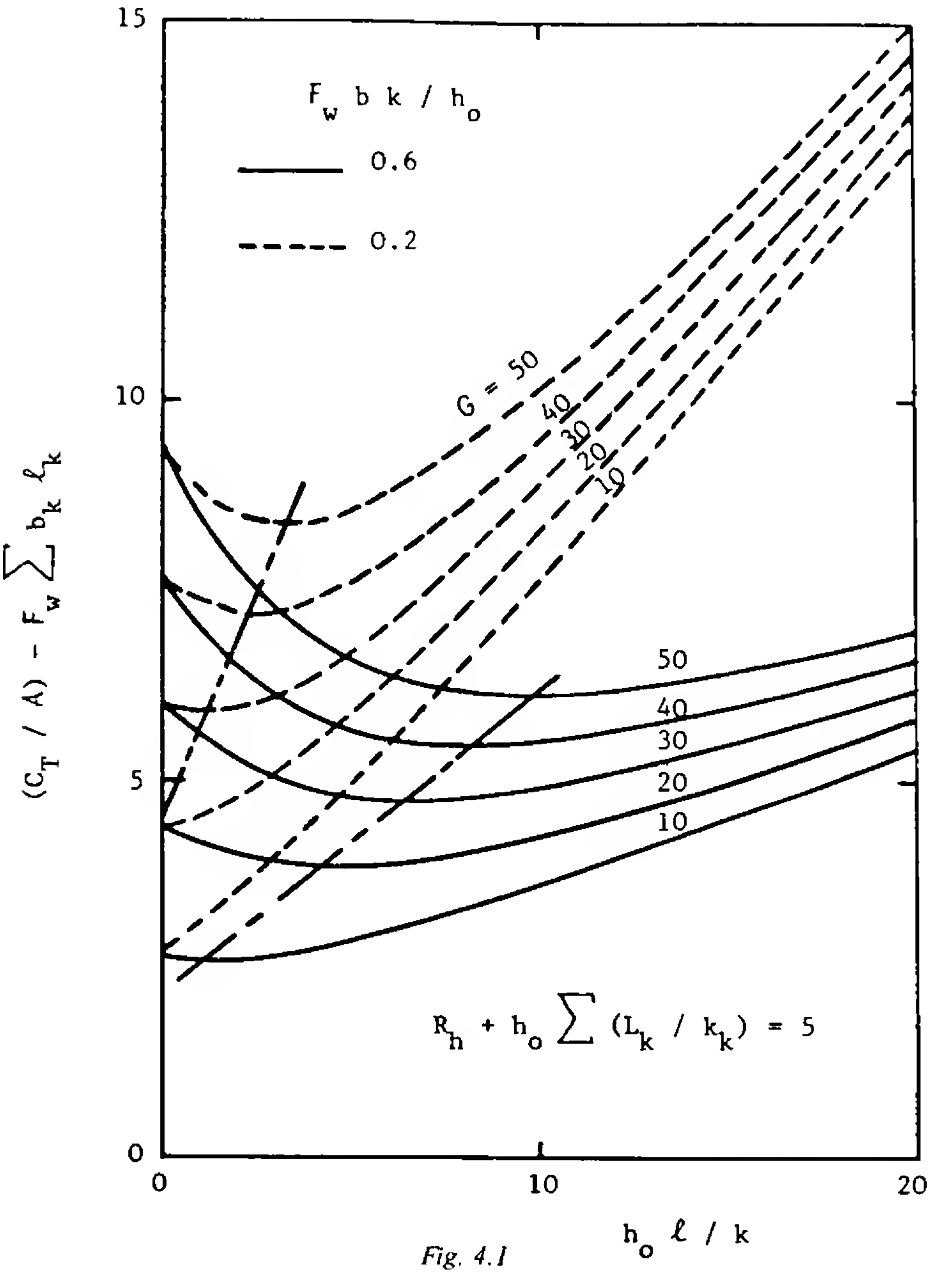


Fig. 4.1

could then be carried directly by the normal procedure of setting the partial derivatives of the objective function with respect to each variable, the l_i's, equal to zero and then solving the resulting equations simultanueously. Such would be n equations as follows

$$\frac{\partial}{\partial \ell_j}\left[\frac{C_T}{A}\right] = F_w b_i - \frac{Gh_o / k_i}{\left[1 + R_h + h_o \sum_{j=1}^{m} \frac{\ell_j^*}{K_j}\right]^2} = 0 \qquad (4.15)$$

The superscript * denotes optimal conditions. Equation (4.15) gives l^*_i from

$$\frac{h_o l^*_i}{k_j} = \sqrt{\frac{G\ h_o}{F_w\ k_i\ b_i}} - h_o \sum_{\substack{j=1 \\ =i}}^{m} \frac{l^*_j}{k_i} - R_h - 1 \qquad (4.16)$$

This, again, is a dimensionless relation. The optimum thicknesses could be obtained by the simultanueous solution of the n equations represented by eqn (4.16).

It should be noted that in some cases where $\Theta_r > \Theta_a$, the quantity G would be negative. In this case there would be not need for summer air conditioning. Indeed, this is expressed by the fact that the radical in eqn (4.16) would have an imaginary value.

Further, $l^*_i \leq 0$ if

$$\sqrt{\frac{Gh_o}{F_w\ k_i\ b_i}} \leq h_o \sum_{\substack{j=1 \\ j=i}}^{m} (l^*_j / k_j) + R_h + 1 \qquad (4.17)$$

The meaning of such a situation is that, economically, the building component is better off without this layer «j» at the position designated.

In the following, some special cases are discussed.

4.6.1 SINGLE-LAYER COMPONENTS

In this case eqn (4.16) becomes

$$\frac{h_o\ l^*}{k} = \sqrt{\frac{G\ h_o}{F_w\ k\ b}} - R_h - 1 \qquad (4.18)$$

If in this case the condition given by (4.17) is satisfied, the meaning is that the costs of energy and equipment are very small relative to those of the component that the least thickness structurally feasible should be used.

4.6.2 FIXED MULTI-LAYER COMPONENT WITH ONE LAYER TO BE OPTIMIZED

This is the case where the thicknesses of the main layers, say k = 1, 2,... are fixed with thicknesses L_k and a single layer of thickness l is to be optimized. In this case, eqn (4.16) becomes

factors other than those of thermal behaviour such as strength, code requirements, etc. This leaves the thicknesses of usually no more than two layers to be optimized. Indeed, the study could be repeated for various combinations of materials; the one that gives the least total annual cost should, of course, be chosen. In most cases, however, the material combinations that could be used would be very limited because of other factors such as temperature and humidity levels, type of atmosphere, etc.

A further difficulty is in evaluating q_p as this entails a knowledge of the instant of the maximum total load on the refrigeration/air conditioning equipment. This instant depends on the time variations of the internal load and of the conductive loads from the various components of the building. The variations of the latters with time depend on the constructions used and should, therefore, enter into the optimization process itself. Under these conditions, the simplest procedure seems to be a trial-and-error one. In this procedure, various dimensions for each of the components are considered. For each of these, the values of q_{max} and q_{av} are determined. For the first trial, the starting values of the q_p's could be taken for each component as $q_p = q_{max} - a_{av}$. The values of q_{av} and q_p thus obtained would be used in eqn (4.7) to determine the total annual costs for the alternative dimensions of each component. The optimum dimensions are the ones that give the least annual cost for each component. The time variation of the total flux from the internal load and all the components could then be obtained. The contribution of each component to the overall maximum flux could then be determined and used to obtain new values of the q_p's for the next trial. Trials are repeated until the solution stabilizes.

4.6 SIMPLIFIED OPTIMIZATION PROCESS

The procedure described above is obviously quite lengthy. Fortunately, in most cases, the last term in eqn (4.7) that contains q_p does not affect the optimization process to any appreciable extent. In such cases, this term could be neglected and optimization would be for the objective functions as given by

$$C_T/A = 1 + F_w \sum_{i=1}^{n} b_i l_i + B q_{av}$$

Here q_{av} could be obtained directly from eqn (3.48) and the above equation becomes

$$C_T/A = 1 + F_w \sum_{i=1}^{n} b_i l_i + \frac{G}{1 + R_h + h_o \sum_{i=1}^{m} \frac{\ell_i}{\lambda_i}} \tag{4.13}$$

where $$G = Bh_r \ \Delta t[R_h(\theta_{a,o} - \theta_r) + N_I R_{I,av}] \tag{4.14}$$

This function is dimensionless and depends on the various costs.

The above form, eqn (4.13), simplifies the process on the computer considerably such that all the calculations could be carried out in a minimal time. The optimization process

1. Had this value been a time function, the procedure recommended in Section 4.7.1 and 2 would have been followed.

4.4 TOTAL ANNUAL COST

The total annual cost is the sum of the above annual costs, i.e.,

$$C_T = C_w + C_U + C_r \qquad D/m^2\ y \tag{4.6}$$

This is the objective function to be minimized to obtain the optimum choice of wall construction and refrigeration/air conditioning equipment. The total cost as given above may better be expressed in dimensionless form as

$$C_T / A = 1 + F_w \sum_{i=1}^{n} b_i \ \ell_j + B\, q_{av} + O\, q_p \tag{4.7}$$

The symbols in the above relation are

$$A = F_w \left[a + \sum_{j=1}^{m} a_j + \sum_{k=n+1}^{m} b_k \ \ell_k \right] \qquad D/m^2\ y \tag{4.8}$$

$$b_i = b_i / A \qquad y/m \tag{4.9}$$

$$B = [(F_U\, c_U / \lambda_U) + 8760\, c_e] / A \qquad m^2/kW \tag{4.10}$$

$$O = F_U\, c_U / A\, \lambda_U \qquad m^2/kW \tag{4.11}$$

$$q_p = q_{max} - q_{av} \qquad kW/m^2 \tag{4.12}$$

q_p is the flux density at time of peak load on the refrigeration/air conditioning unit.

The subscript i indicates layers to be optimized, while subscript k denotes layers of predetermined thicknesses.

Where two separate units for heating and cooling are to be used, eqns (4.9 and 10) may be modified according to eqns (4.3a, 4a and 5a).

4.5 OPTIMIZATION PROCESS

Theoretically, one should be able to express the total annual cost as a function of the controllable variables, mainly materials properties and thicknesses. Optimization could then be obtained by the partial differentiation of the total annual cost with respect to these variables and equating to zero [19,20]. Unfortunately, this is practically impossible, not only the physical properties could not be separated and/or functionally related to the cost, but also because relations between properties and dimensions on one hand and the flux variation with time on the other hand are very complex. Further, the dimensions of the important building and insulating materials (stones, bricks, cork board, etc.) are standardized and, hence, it is not always practical to set the cost as a continuous function of the layers' thicknesses.

The economic analysis could be made for simple or composite components. In the general case of multi-layer components, the method suggested is to start by choosing the thicknesses of the main and finishing layers. The materials used for such layers are usually of standardized dimensions and the choice of the thicknesses is governed by

a function of the total capacity and, within a range under consideration, this function is virtually linear. Hence the first cost of the refrigeration/air conditioning unit and its auxiliaries per unit area of the building component could be given by

$$C_U = c_U\, q_{max} /\ \lambda_U \qquad D/m^2 \qquad (4.3)$$

Here c_U is the cost of equipment per unit capacity in D/kW,

$$q_{max} = (q_c + q_i)_{max} \qquad kW/m^2$$

λ_U is the utilization factor = maximum load / capacity

The fixed charge rate F_U for the regrigeration/air conditioning unit could be determined. Generally it is not the same as F_w since the equipment life, insurance, etc. may not be the same as those of the building components. The fixed annual cost of the unit(s), auxiliaries, etc. would be

$$C_U = F_U\, C_U = F_U\, c_U\, q_{max} /\ \lambda_U \qquad D\ m^2\ y \qquad (4.4)$$

4.3.2 RUNNING COST

This cost usually accounts for a large fraction of the total cost. It includes the cost of energy together with costs of maintenance, wages of machine room operator(s), etc. The running cost depends on the service to which the equipment is subjected and, hence, usually taken as proportional to the energy consumption This energy could be calculated as the product of the average energy by the number of hours in a year (8760 h/y) and prorated to a unit area of the building component. Again, the average nergy is the sum of conductive and internal parts that could be determined as outlined before. If this average is $q_{av} = (q_c + q_i)_{av}$ in kW/m2, and the overall cost is c_e(D/kW h), the total running cost would be

$$C_r = 8760\, c_e\, q_{av} \qquad D/m^2\, y \qquad (4.5)$$

It should be noted that c_e includes not only the unit energy price, but also the other running expenses prorated to a kW h.

In certain cases, one may have to use separate units for heating and cooling, rather than a single air conditioning unit (heat pump). In such a case one would have to consider each season separately and calculate the various costs as the sums of two parts. Thus eqn (4.3) becomes

$$C_U = C_{U,H} + C_{U,C} = c_{U,H}\, q_{H,max} /\ \lambda_{U,H} + c_{U,C}\, q_{C,max} /\ \lambda_{U,C} \qquad (4.3a)$$

Also, eqn (4.4) becomes

$$C_U = F_{U,H} \cdot C_{U,H} + F_{U,C}\, C_{U,C} \qquad (4.4a)$$

Similarly, eqn (4.5) would be replaced by

$$C_r = P_H\, (c_{e,H}\, q_{av,H}) + P_C\, (c_{e,C}\, q_{av,C}) \qquad (4.5a)$$

In the above relations P stands for period of operation in hours per year, and subscripts H and C stand for heating and cooling units, respectively.

2 —Expenses that depend purely on area and type of construction such as mortar, adhesives to be used with some insulating materials, etc. To these one may add the overhead charges. The sum of these costs per unit wall area will be denoted by, a, in D /m2.

3 —costs that depend on the type of material used, but not its size or weight. Such costs are those of special handling, transportation, storage, etc. The sum of these costs for material j are denoted by a_j. in D/m2.

4 —Costs that are specific to the material used and proportional to its volume or weight. Examples are the cost of material itself, part of its packing, transportation, storage and handling, etc. The aggregate of such costs per unit volume of material j is denoted by b_j, D/m3.[1]

Summing up the above, the total cost per unit area of a composite wall of m layers would be given by

$$C_w = a + \sum_{j=1}^{m} (a_j + b_j \ \ell_j) \quad D/m^2 \tag{4.1}$$

Here, as before, ℓ_j is the thickness of layer j.

Since in this analysis, comparison is of the total annual cost, the fixed annual cost per unit area should be determined; it may be calculated as a fraction F per year, the so-called fixed charges rate. It is the sum of the fixed annual expenses as fractions representing the annual interest rate, depreciation rate, insurance rate, etc. Hence, the fixed annual cost of the wall is given by

$$C_w = F_w \ C_w \qquad D/m^2y \tag{4.2}$$

4.3 REFRIGERATION/AIR CONDITIONING COST

The cost of refrigeration/air conditioning could be divided into two parts. One is the first cost of the equipment and the other is the cost of its operation.

4.3.1 EQUIPMENT COST

The equipment required would be heating units(s) for the winter months, cooling unit(s) for the summer months or refrigeration unit(s) for cooling a cold store throughout the year, together with their necessary plumbing and electric connections, space, foundation, etc. The capacity of a unit depends on the maximum load it will carry in kW and the utilization factor commonly used for the type.

The load on a unit could be divided into two general parts: the conductive and the internal parts. The first, the conductive part denoted by q_c, could be determined by the methods described in the previous chapters and is prorated to a unit area of the wall. The internal load, denoted by q_i, would be that of occupancy, infilteration, etc., is independent of the component construction and could be determined by the methods described in refrigeration and air conditioning texts and, again, should be prorated to a unit area of the wall.

The maximum load on a unit thus calculated and the utilization factor chosen, the unit capacity per unit area could be determined. From these, the auxiliaries cost and, hence, the total cost could be calculated and prorated to a unit wall area. The total cost is

---

1. D = dinar.

4.1 INTRODUCTION

The general engineering problem is an economic one. Many designs and constructions could be conceived to fulfill a given set of requirements: function, durability, etc. The choice of a particular solution is an optimization process where the requirements are met with the least possible expense.

For a building, the present discussion will be limited to the case where the indoors temperature is positively controlled, throughout the year, by a refrigeration or an air conditioning unit. With all the other basic requirements fulfilled, the economic problem becomes that of the walls constructions. A better insulated wall, either by being thicker or by adding a layer of an insulating material, is more expensive. However, such a wall would ultimately require a smaller and less expensive refrigeration/air conditioning unit, and would also save on the energy required for its operation. Epitomized, a more expensive construction would save on the first cost of the refrigeration/air conditioning unit and its consumption, and vice versa. The economic problem is, essentially, to balance these factors – namely the first cost of the wall and refrigeration/air conditioning unit, and the running cost of the unit – to minimize the total final cost, usually in the form of a total annual cost.

In this chapter, the various costs are discussed. They are separated to fixed or first costs, and running costs. The fixed costs are used to obtain the so-called fixed annual cost which, when added to the running costs would give the total annual cost. This latter cost is the objective function to be minimized to give the optimum design.

Because the thermal load calculations, essential for sizing the refrigeration/air conditioning unit and determining its energy consumption, are based on a unit area of the wall, all the costs discussed above will be prorated to a unit wall area.

4.2 WALL COST

Considering a wall of m layers (usually within four), the total cost of this wall per unit area could be divided into the following parts:

1 —A cost that is independent of the type of wall or its construction. Examples are costs of architectural design, skeleton, purchasing, finishing and painting, etc. While this cost has to be taken into account in calculating the total expenditure, it could be neglected in comparative economic studies, being the same for all alternatives. Overhead charges should be included in this category; however, the common practice is to estimate these charges as a percentage of the expenditure and, hence, would be included in this study.

Chapter 4

ECONOMIC ANALYSIS

The contents of this chapter were presented at the ASME 1981 Sobar Energy Third Annual Conference, Reno, NIVADA, U.S.A. April/May 1981.

3.6.2 EFFECT OF WALL ORIENTATION

Figure 3.6 shows the distribution of the flux density and its average for three composite walls of the same construction but different orientations in the northern hemisphere. The three walls have the same maximum insulation I_{max}. As could be seen, the least maximum and average are those for the north facade, being practically unexposed to the sun. The highest maximum and average are those of the south facing wall. The reason is that such a facade is exposed to the sun longer than the other orientations. Further, the maximum for the south-facing wall occurs later in the day than that of the east facade because the maximum insulation for the former occurs at solar noon, whereas that of the latter takes place much earlier in the day.

For the north facade, it is not exposed to the sun and, therefore, the maximum and average fluxes through it are the least, being due to the effect of the outside air temperature only.

3.7 CONCLUSIONS

In this chapter the general problem of composite components with isotropic homogeneous layers is formulated and two methods of solution are presented. These methods are given in a rather general form relying on the previous chapter for the details.

Illustrative numerical examples for two-layer components are solved and discussed as to the effects of orientation and relative position of the insulating layer. The computer program used is given in Appendix B and some results are compiled in Appendix D for further use by the reader.

Further, the figure shows that placing the insulation on the room side, for the same materials combination, reduces the maximum heat flux density. This would also reduce the capacity of the refrigerating/air conditioning unit that would be needed as shown in the next chapter. This trend is the reverse of that found earlier in a similar problem with uncontrolled air temperature [4]. The complexity of the problem makes it virtually impossible to state explicitly general conditions for such a reversal of trend. Such a condition may be visualized, for example, for the case of a component thick enough that the first harmonic dominates its thermal behaviour. In such a case, the exchange of the positions of the second and third matrices on the right hand side of eqn (3.47) for the first harmonic may change the value of the heat flux density as given by the differential $d\ \Theta_{2,2}/dX_2$. This, of course, happens only for certain conditions and relative property values of the two layers.

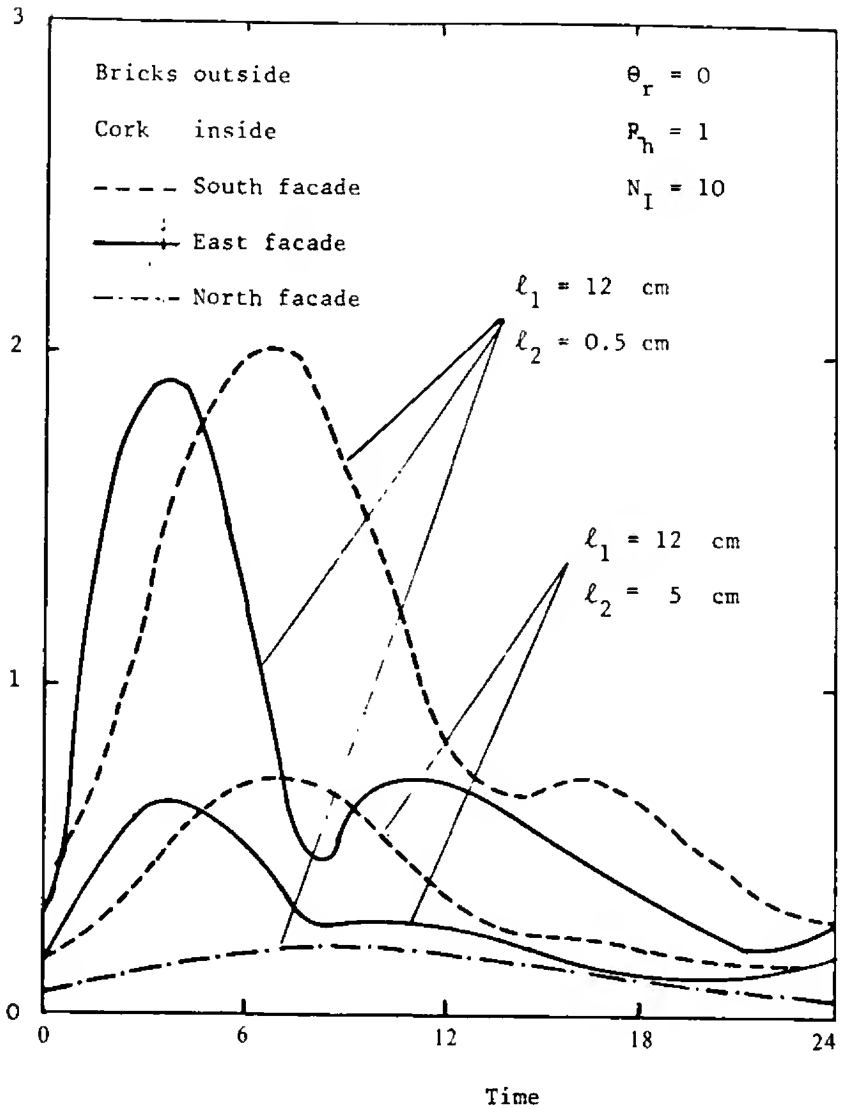


Fig. 3.6

Figure 3.5 shows the effect of the relative thicknesses of the main and insulating layers. In all cases the insulating layer is 1 cm thick, whereas the main layer thickness varies between 5 and 20 cm.

3.6.1 EFFECT OF RELATIVE POSITION OF LAYERS

Figure 3.5 shows qualitatively the interesting effect of the relative position of the two layers on the indoors heat flux density. The average heat flux, being the steady-state part given by eqn (3.48), is not affected by the relative position of the layers.

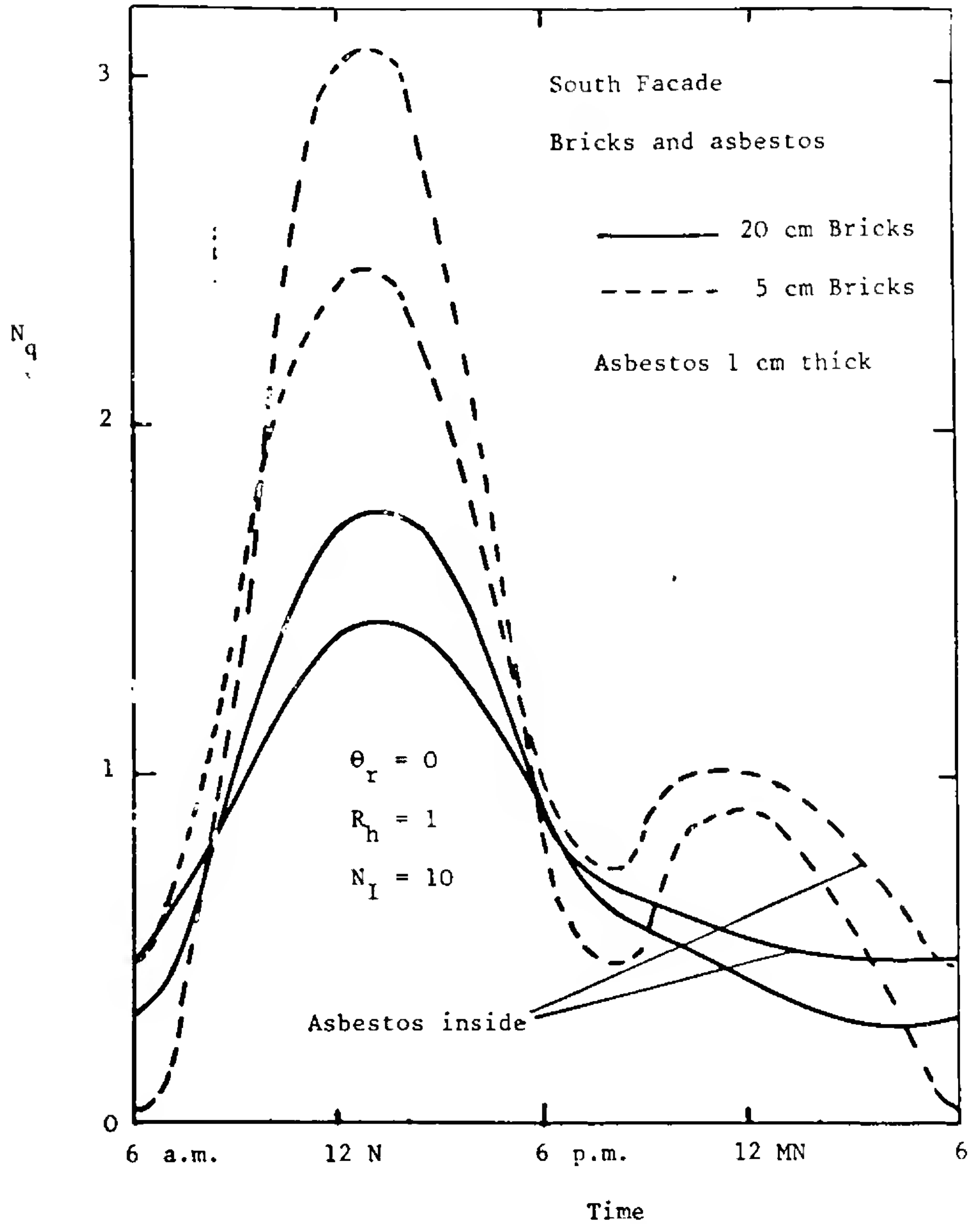
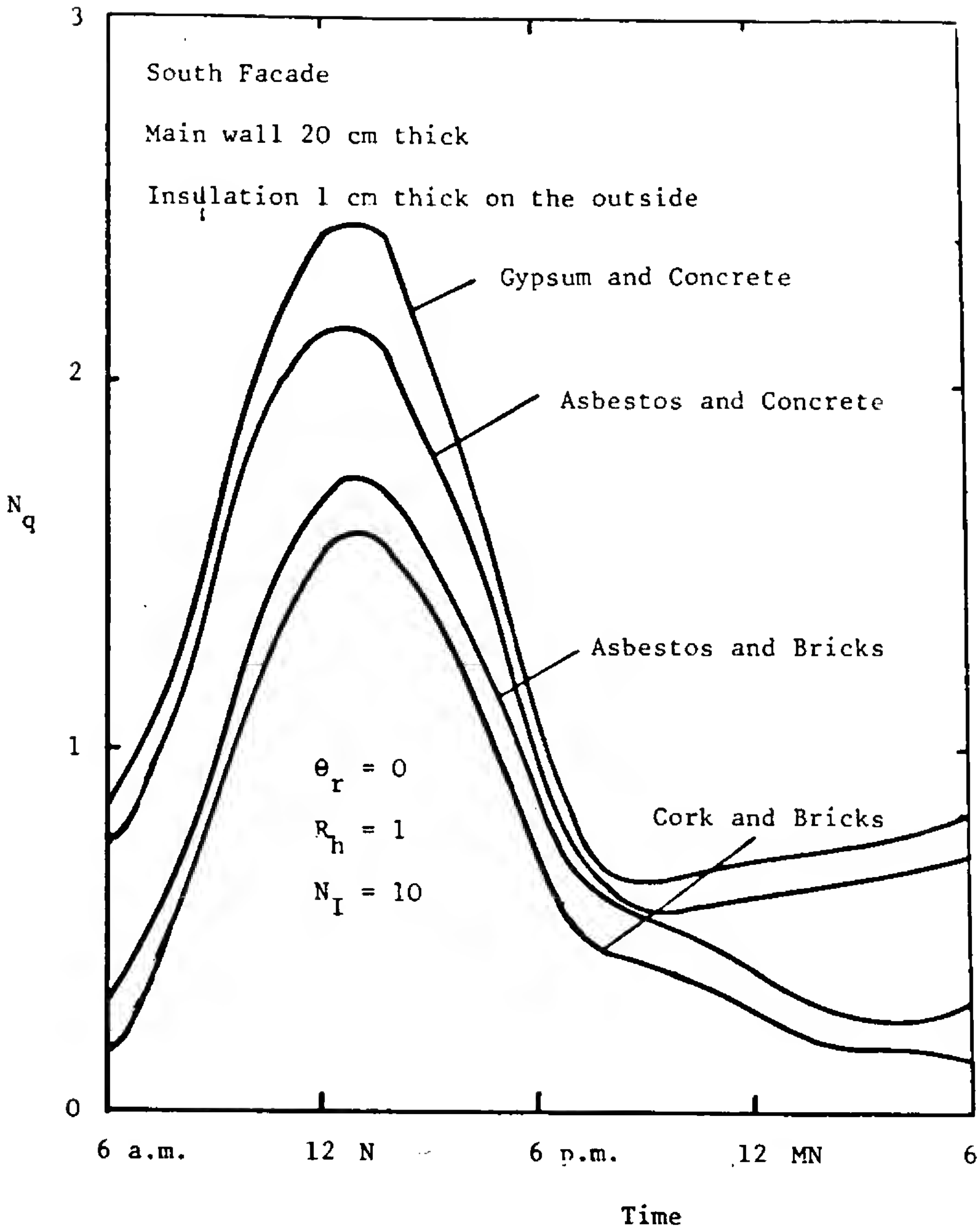


Fig. 3.5



South Facade
Main wall 20 cm thick
Insulation 1 cm thick on the outside
Gypsum and Concrete
Asbestos and Concrete
Asbestos and Bricks
Cork and Bricks
$\theta_r = 0$
$R_h = 1$
$N_I = 10$
N_q
3
2
1
0
6 a.m.
12 N
6 p.m.
12 MN
6
Time

Fig. 3.4

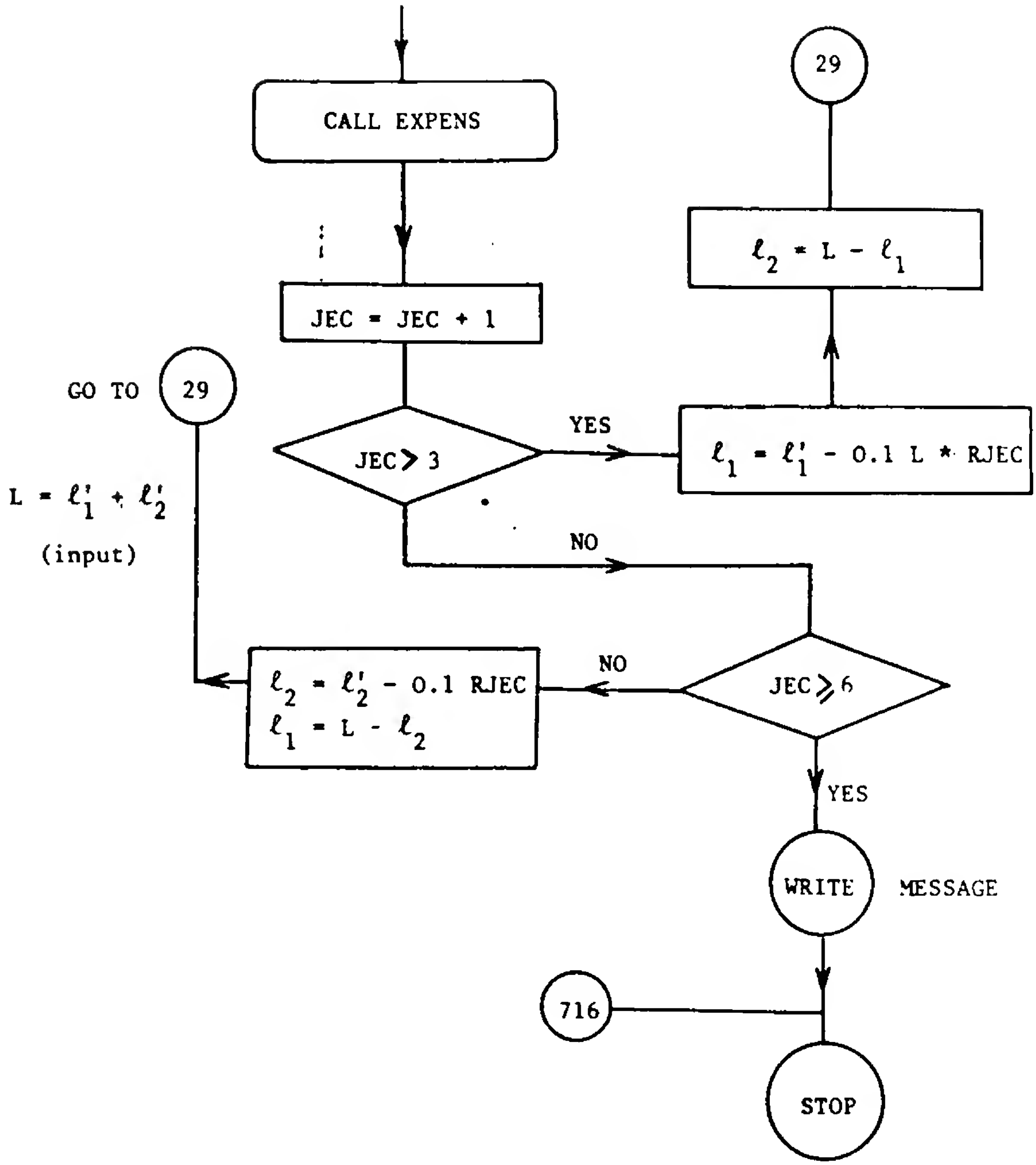
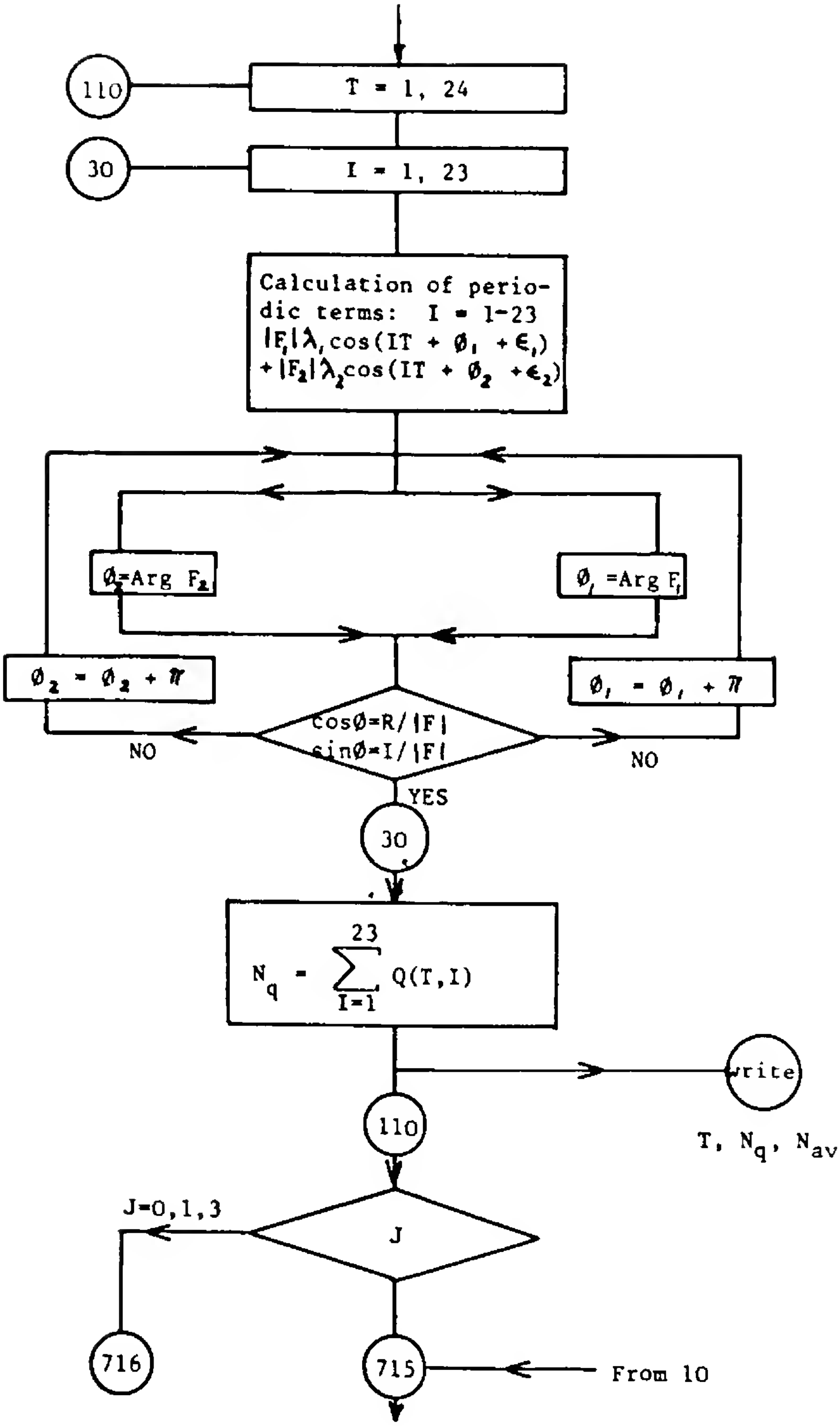
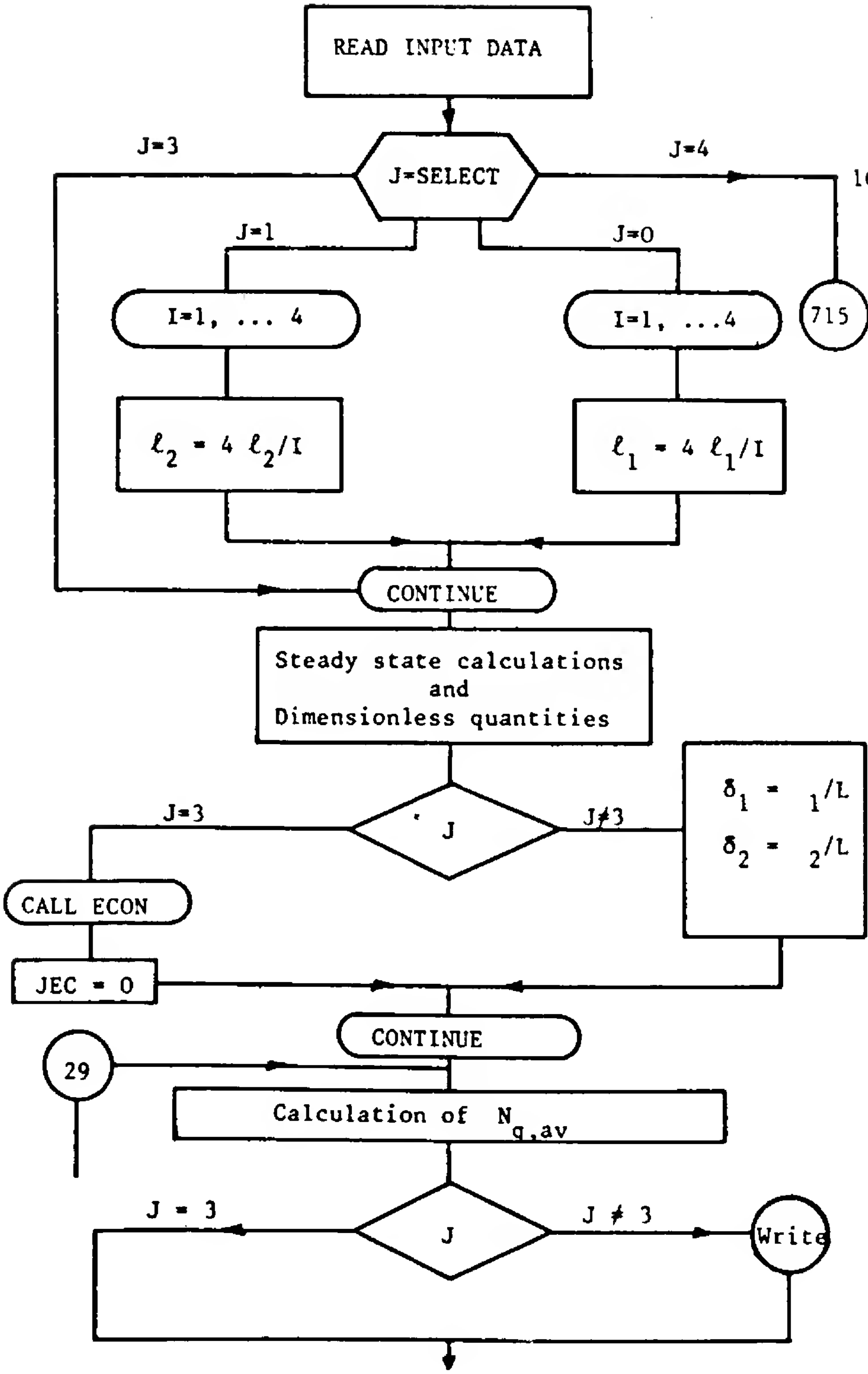

CALL EXPENS
JEC = JEC + 1
JEC > 3
YES
NO
ℓ₁ = ℓ'₁ - 0.1 L * RJEC
ℓ₂ = L - ℓ₁
29
GO TO 29
L = ℓ'₁ + ℓ'₂
(input)
ℓ₂ = ℓ'₂ - 0.1 RJEC
ℓ₁ = L - ℓ₂
NO
JEC ≥ 6
YES
WRITE
MESSAGE
716
STOP

Fig. 3.3c



110
T = 1, 24
30
I = 1, 23
Calculation of periodic terms: I = 1-23
$|F_1|\lambda_1\cos(IT + \phi_1 + \epsilon_1) + |F_2|\lambda_2\cos(IT + \phi_2 + \epsilon_2)$
ϕ_2=Arg F_2
ϕ_1 =Arg F_1
$\phi_2 = \phi_2 + \pi$
$\phi_1 = \phi_1 + \pi$
cosϕ=R/|F|
sinϕ=I/|F|
NO
NO
YES
30
$N_q = \sum_{I=1}^{23} Q(T,I)$
write
T, N_q, N_{av}
110
J=0,1,3
J
716
715
From 10

Fig. 3.3b



READ INPUT DATA
J=3
J=SELECT
J=4
10
J=1
J=0
I=1, ... 4
I=1, ...4
715
$\ell_2 = 4\ \ell_2/I$
$\ell_1 = 4\ \ell_1/I$
CONTINUE
Steady state calculations and Dimensionless quantities
J=3
J
J≠3
$\delta_1 = {}_1/L$
$\delta_2 = {}_2/L$
CALL ECON
JEC = 0
CONTINUE
29
Calculation of $N_{q,av}$
J = 3
J
J ≠ 3
Write

Fig. 3.3a

While this form seems to be more complicated than that of eqn (3.35), its use is straightforward and it gives directly the flux in the transformed domain, hence less time consuming.

3.5 SOLUTION PROCEDURE

The objective of the present study is to determine the load on, and size of, a refrigeration or an air conditioning unit that maintains a constant indoor air temperature Θ_r. The reduced flux $d\Theta_{m,2}/dX_m$ could be determined from the general method of solution of eqn (3.24) as described in Sect. 3.3 where A_m and B_m are determined. Alternatively, this flux could be obtained directly from eqn (3.44). The result would have a form similar to that of eqn (2.22) which would have steady, radiative and convective parts.

The steady-state part gives the average heat flux and could be shown to be given by

$$N_{q,av} = q_{av} / h_r \ \Delta t = (k_m / h_r \ \ell_m)(\partial\Theta_{m,2}/ \partial X_m)$$

$$= \frac{R_h(\Theta_{a,o} - \Theta_r) + N_I R_{I,av}}{1 + R_h + h_o \sum_{j=1}^{m} \frac{\ell_j}{k_j}} \qquad (3.48)[1]$$

The established state radiative and convective parts could be determined as before in Chapter 2 as factors of $\bar{R}_I$ and $\bar{\Theta}_a$, respectively. Their transfer functions, similar to those of eqns (2.23 and 24), could also be determined for any general harmonic n. The process could be carried out after that in exactly the same manner as in Sect 2.3.2.3 and 4.

3.6 NUMERICAL CALCULATIONS FOR TWO-LAYER WALLS

The general method was used to solve the problem of two-layer components. A computer program, written in FORTRAN IV for IBM-370 computer is given in Appendix B to solve two-layer problems, using the general method of Sect. 3.3. The block diagram for the algorithm used is shown in Fig. 3.3. Solutions for some cases where $\Theta_r=0$, $N_I=10$ and $R_h=1$ were carried out with properties taken from Appendix C. Copies of the print-out sheets are given in Appendix D for later use by designers, they give the variation of the dimensionless indoors flux with time.

Some of the results are shown graphically to illustrate specific points. Figure 3.4 shows a general comparison between the various materials with the insulation on the outside surface of the main layer. This figure shows that bricks are better than concrete for the main layer; and that for outside insulation, cork is best and gypsum the least effective. Merit is indicated by the values of the maximum and average heat fluxes. In the cases presented, higher maximum heat flux is accompanied by a higher average value.

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1. The numerator of this equation corresponds to the difference between the indoor temperature and the «sol-air temperature».

$$\begin{bmatrix} \cosh p_1 & \sinh p_1 / p_1 \\ p_1 \sinh p_1 & \cosh p_1 \end{bmatrix} \begin{bmatrix} 1 & (N_B R_h)^{-1} \\ 0 & 1 \end{bmatrix} \times$$

$$\begin{bmatrix} \overline{\theta}_a + (N_I \overline{R}_I / R_h) \\ N_B R_h(\overline{\theta}_{1,1} - \overline{\theta}_a) - N_B N_I \overline{R}_I \end{bmatrix} \qquad (3.44)$$

3.4.5 TWO-LAYER COMPONENTS

The simple case of Section 3.3.1 could be restated in the present form as

$$\begin{bmatrix} \overline{\theta}_r \\ d\overline{\theta}_{2,2} / dX_2 \end{bmatrix} = \begin{bmatrix} 1 & k_2/k_1 N_B \\ 0 & 1 \end{bmatrix} \times$$

$$\begin{bmatrix} \cosh p_2 & k_1 \ell_2 \sinh p_2 / k_2 \ell_1 p_2 \\ p_2 \sinh p_2 & k_1 \ell_2 \cosh p_2 / k_2 \ell_1 \end{bmatrix}$$

$$\times \begin{bmatrix} \cosh p_1 & \sinh p_1 / p_1 \\ p_1 \sinh p_1 & \cosh p_1 \end{bmatrix} \times$$

$$\times \begin{bmatrix} 1 & (N_B R_h)^{-1} \\ 0 & 1 \end{bmatrix} \times$$

$$\begin{bmatrix} \overline{\theta}_a + (N_I \overline{R}_I / R_h) \\ N_B R_h(\overline{\theta}_{1,1} - \overline{\theta}_a) - N_B N_I \overline{R}_I \end{bmatrix} \qquad (3.47)$$

As could be seen, the first form, eqn (3.42a) is best suited for the outside layer, j=1; the second form, eqn (3.42b) is best suited for the other layers, j=2,3,...,m.

3.4.3 OUTSIDE SURFACE

The relation to be used here is the boundary condition, eqn (3.19); in matrix form it becomes

$$\begin{bmatrix} \bar{\Theta}_{1,1} \\ \dfrac{d\bar{\Theta}_{1,1}}{dX_1} \end{bmatrix} = \begin{bmatrix} 1 & (N_B R_h)^{-1} \\ 0 & \end{bmatrix} \begin{bmatrix} \bar{\Theta}_a + (N_I \bar{R}_I / R_h \\ N_B R_h (\bar{\Theta}_{1,1} - \bar{\Theta}_a) - N_B N_I \bar{R}_I \end{bmatrix} \qquad (3.43)$$

3.4.4 COMPLETE RELATION

The value for the right hand side vector of eqn (3.41) is substituted from eqn (3.42b). This substitution is then carried out successively using the latter equation to the outside layer (j=1) where eqn (3.42a) is used. The right hand side component of this relation is then substituted from eqn (3.43). This gives eqn (3.44) on the following page. This relation yields two equations in two unknowns. In the present case where $\bar{\Theta}_r$ is given, these unknowns are $\bar{\Theta}_{1,1}$ and $d\,\bar{\Theta}_{m,2}/dX_m$; the latter is the more important quantity as it gives the flux into the room, namely

$$\frac{d\Theta_{m,2}}{dX_m} = \frac{q_{m,2}\ \ell_m}{k_m\ \Delta t} = N_q N_B k_I\ \ell_m/k_m\ \ell_I \qquad (3.45)$$

or

$$N_q = \frac{d\Theta_{m,2}}{dX_m}\ (k_m\ \ell_1/k_I\ \ell_m N_B) \qquad (3.46)$$

The temperature and flux at the outside surface could then be obtained from eqn (3.43).

$$\begin{bmatrix} \bar{\theta}_r \\ d\bar{\theta}_{m,2} / dX_m \end{bmatrix} =$$

$$\begin{bmatrix} 1 & k_m/k_1\ N_B \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \cosh p_m & k_{m-1}\ \ell_m\ \sinh p_m / k_m\ \ell_{m-1}\ p_m \\ p_m\ \sinh p_m & k_{m-1}\ \ell_m\ \cosh p_m / k_m\ \ell_{m-1} \end{bmatrix}$$

$$x\ \ldots\ x\ \ldots \begin{bmatrix} \cosh p_2 & k_1\ \ell_2\ \sinh p_2 / k_2\ \ell_1\ p_2 \\ p_2\ \sinh p_2 & k_1\ \ell_2\ \cosh p_2 / k_2\ \ell_1 \end{bmatrix} x$$

3.4.1 INNERMOST SURFACE

The energy balance at the innermost surface is represented by the transformed eqn (3.20), it gives in matrix form the room temperature and flux

$$\begin{bmatrix} \bar{\Theta}_r \\ d\bar{\Theta}_{m,2}/dX_m \end{bmatrix} = \begin{bmatrix} 1 & k_m/k_1\, N_B \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \Theta_{m,2} \\ d\,\bar{\Theta}_{m,2}/dX_m \end{bmatrix} \qquad (3.41)$$

3.4.2 INTERMEDIATE COMPONENT

The boundary value problem to be solved in this case would be eqn (3.28) with the boundary conditions given by eqns (3.21 and 22). For no thermal contact resistance, the problem becomes

$$\frac{d^2\bar{\Theta}_j}{dX_j^2} - p_j^2\ \bar{\Theta}_j = 0 \qquad (3.18)$$

$$\frac{d\bar{\Theta}_{j,1}}{dX_j} = R_{k,j-1}\frac{d\bar{\Theta}_{j-1,2}}{dX_j} \qquad (3.21a)$$

$$\bar{\Theta}_{j,1} = \bar{\Theta}_{j-1,2} \qquad (3.22a)$$

The general solution of eqn (3.18) is given by eqn (3.23). Using this equation and eqn (3.24) with the boundary conditions give

$$\bar{\Theta}_{j,2} = \bar{\Theta}_{j,1}\cosh p_j + \frac{\sinh p_j}{p_j}\,\frac{d\bar{\Theta}_{j,1}}{dX_j}$$

$$\frac{d\bar{\Theta}_{j,2}}{dX_j} = {}_{j,1}\, p_j \sinh p_j + \frac{d\bar{\Theta}_{j,1}}{dX_j}\cosh p_j$$

In matrix form, these relations become

$$\begin{bmatrix} \bar{\Theta}_{j,2} \\ \dfrac{d\bar{\Theta}_{j,2}}{dX_j} \end{bmatrix} = \begin{bmatrix} \cosh p_j & \dfrac{\sinh p_j}{p_j} \\ p_j \sinh p_j & \cosh p_j \end{bmatrix} \begin{bmatrix} \bar{\Theta}_{j,1} \\ \dfrac{d\bar{\Theta}_{j,1}}{dX_j} \end{bmatrix} \qquad (3.42a)$$

$$= \begin{bmatrix} \cosh p_j & \dfrac{R_{k,j-1}}{p_j}\sinh p_j \\ p_j \sinh p_j & R_{k,j-1}\cosh p_j \end{bmatrix} \begin{bmatrix} \bar{\Theta}_{j-1,2} \\ \dfrac{d\bar{\Theta}_{j-1,2}}{dX_j} \end{bmatrix} \qquad (3.42b)$$

The solution of this matrix is quite tedious; however. It could be handled rather easily by a computer and is most general in the sense that it can give the temperature distribution at any point within the wall at any instant of time. Explicit relations could be obtained from this solution for various values of m, but they are very complicated even for two layers (m=2). The matrix is most useful for numerically-defined problems where manipulation will be of numbers rather than symbols. Of course, numerical solutions are best carried out by a computer that could easily handle complex quantities.

3.3.1 TWO-LAYER COMPONENTS

To illustrate the method of solution outlined above, the simple case of two-layer components where the indoor temperature is controlled, i.e., for Θ_r = constant, hence $\bar{\Theta}_r = \Theta_r/s$ is given below in matrix form

$$\begin{bmatrix} 1 & K & 0 & 0 \\ \exp(p_1) & \exp(-p_1) & -1 & -1 \\ M_1 & -N_1 & -1 & 1 \\ O & O & \exp(p_2) & L \end{bmatrix} \begin{bmatrix} A_1 \\ B_1 \\ A_2 \\ B_2 \end{bmatrix} = \begin{bmatrix} S \\ O \\ O \\ \mathcal{T} \end{bmatrix} \tag{3.35}$$

Solution of the above matrix gives the following expressions for the integration constants.

$$A_1 = [2\,k\mathcal{T} - S\exp(-p_1)\{L + \exp(p_2)\} - S\,N\,(L - \exp(p_2)]/D \tag{3.36}$$

$$B_1 = [-2\,\mathcal{T} + S\{M + \exp(p_1)\}\{L + \exp(p_2\} - 2\,S\,L\,M]/D \tag{3.37}$$

$$A_2 = [(\mathcal{T} + K\mathcal{T} + LN)\ \{M + \exp(p_1)\} + (\mathcal{T} + S\,L\,M)\{N - \exp(-p_1)\}]/D \tag{3.38}$$

$$B_2 = [S\exp(p_2)\ \{N\exp(p_1) + M\exp(-p_1)\} - K\,\mathcal{T}\{M - \exp(p_1)\} - \mathcal{T}\ \{N + \exp(-p_1)\}]/D \tag{3.39}$$

where

$$D = [L + \exp(p_2)]\,[K - \exp(-p_1)] + (N - K\,M)\,[L - \exp(p_2)] \tag{3.40}$$

The above values could then be used in eqns (3.23 and 24) to determine the temperature distribution and heat flux density, both in the transformed domain. Note that M stands for M_1 and N for N_1.

3.4 ALTERNATIVE METHOD OF SOLUTION

As mentioned before, the general method of solution is quite tedious but general. In most cases, the temperature distribution in the wall is not required and solution is needed only for the thermal flux into the building. For such cases, a much simpler formulation could be used; it is based on a method used by Carslaw and Jaeger [18] for a simpler case. In this method, the temperature and flux at the inner interface, denoted by «2», of a layer are obtained in terms of their values at the other, and outer, interface of the same layer denoted by «1». Using these relations successively together with eqns (3.21 and 22), the solution would be presented as a multiple of m+2 second order square matrices. The formulation would be as follows.

$$N_j = k_j\, p_j \exp(-p_j) \,/\, k_{j+1}\, p_{j+1} \tag{332}$$

$$S = (N_B R_h \overline{\Theta}_a + N_B N_l \overline{R}_l) \,/\, (N_B R_h - p_l) \tag{3.33}$$

$$\tau = N_B \overline{\Theta}_r (k_l/k_m) \,/\, [N_B (k_l/k_m) + p_m] \tag{3.34}$$

3.3 GENERAL METHOD OF SOLUTION

The simultaneous solution of eqns (3.18 to 22) is not straightforward. Solution is simplified by considering three different types of layers: an outside layer, j=1; an intermediate layer, 1 j m, and the innermost layer, j=m. For all layer types, eqn (3.18) applies; a general solution of which is

$$\overline{\theta}_j = A_j \exp(p_j X_j) + B_j \exp(-p_j X_j) \tag{3.23}$$

This solution gives

$$\frac{d\overline{\theta}_j}{dX_j} = p_j [A_j \exp(p_j X_j) - B_j \exp(-p_j X_j)] \tag{3.24}$$

Neglecting henceforth any thermal contact resistances at interfaces, two common boundary conditions exist for all inner interfaces, namely eqn (3.21) without the middle term, and eqn (3.22). Both of these relations when substituted into eqns (3.23 and 24) give, respectively, for the general surface $X_j = 1$, $j = 1, 2, .., m-1$

$$A_j \exp(p_j) + B_j \exp(-p_j) = A_{j+1} + B_{j+1} \tag{3.25}$$

and $R_{k,j}\, p_j\, [A_j \exp(p_j) - B_j \exp(-p_j)] = p_{j+1}\, (A_{j+1} - B_{j+1})$

or $$\frac{\ell_{j+1}\, k_j\, p_j}{\ell_j\, k_{j+1}\, p_{j+1}} [A_j \exp(p_j) - B_j \exp(-p_j)] = A_{j+1} - B_{j+1} \tag{3.26}$$

The above two relations, eqns (3.25 and 26), are the only boundary conditions for intermediate layers: $j = 2,3,..., m-1$.

For the outside layer, $j = 1$, eqn (3.19) is applicable; when substituted into eqn (3.24) it gives

$$A_1\, (p_1 - N_B\, R_h) = B_1(p_1 + N_B\, R_h) - N_B\, R_h\, \overline{\theta}_a - N_B\, N_I\, \overline{R}_I \tag{3.27}$$

For the innermost layer, $j = m$, eqn (3.20) gives

$$A_m\, (p_m + N_B \frac{k_1}{k_m}) \exp(p_m) = B_m\, (p_m - N_B \frac{k_1}{k_m}) \exp(-p_m) + N_B \frac{k_1}{k_m}\, \overline{\theta}_r \tag{3.28}$$

Equations (3.25 to 28) give a system of algebraic equations that have to be solved simultaneously to determine the factors: the A's and B's. This could best be carried out through the matrix given on next page. In this matrix

$$K = (N_B\, R_h + p_1) / (N_B\, R_h - p_1) \tag{3.29}$$

$$L = [N_B\, (k_1/k_m) - p_m] / [N_B\, (k_1/k_m) + p_m] \tag{3.30}$$

$$M_j = k_j\, p_j \exp(p_j) / k_{j+1}\, p_{j+1} \tag{3.31}$$

$$\left.\frac{d\overline{\Theta}_1}{dX_1}\right|_{X_1=0} = N_B R_h(\overline{\Theta}_o - \overline{\Theta}_a) - N_B N_I \overline{R}_I \tag{3.19}$$

$$\left.\frac{d\overline{\Theta}_m}{dX_m}\right|_{X_m=1} = N_B \frac{k_1}{k_m}(\Theta_r - \overline{\Theta}_{m,2}) \tag{3.20}$$

$$R_{k,j}\left.\frac{d\overline{\Theta}_j}{dX_j}\right|_{X_j=1} = N_{U,j}(\overline{\Theta}_{j+1,1} - \overline{\Theta}_{j,2}) = \left.\frac{d\overline{\Theta}_{j+1}}{dX_{j+1}}\right|_{X_{j+1}=0} \tag{3.21}$$

$$\overline{\Theta}_j(1) = \overline{\Theta}_{j+1}(0) \tag{3.22}$$

This set up of the problem is shown graphically in Fig. 3.2.

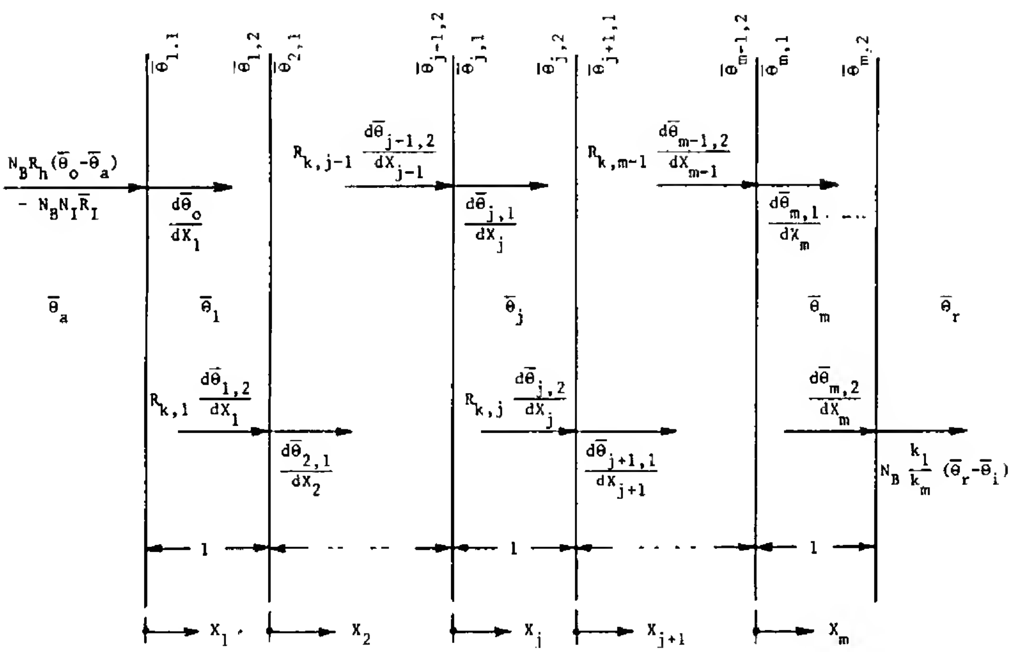


Fig. 3.2

$$N_I = \in I_{max} / h_r \; \Delta t \tag{3.9}$$

$$N_{U,j} = U_j \; \ell_{j+1} / k_{j+1} \tag{3.10}$$

$$R_{k,j} = k_j \; \ell_{j+1} / k_{j+1} \quad j \tag{3.11}$$

Equation (3.8) defines m parameters for j= 1,2,... m, whereas each of eqns (3.10 and 11) definie m-1 parameters for j=1,2,..., m-1.

With the above dimensionless groups, eqns (3.1 to 6) become, respectively,

$$\frac{\partial^2 \theta_j}{\partial X_j^2} \quad \frac{1}{N_{F,j}} \quad \frac{\partial \theta_j}{\partial T} = 0 \tag{3.12}$$

$$\theta_j (X_j, T) = \theta_j (X_j, T+M) \tag{3.13}$$

$$\left.\frac{\partial \theta_1}{\partial X_1}\right|_{X_1 = 0} = N_B R_h (\theta_{1,1} - \theta_a) - N_B N_I R_I \tag{3.14}$$

$$\left.\frac{\partial \theta_m}{\partial X_m}\right|_{X_m = 1} = N_B \frac{k_1}{k_m} (\theta_r - \theta_{m,2}) \tag{3.15}$$

$$R_{k,j} \left.\frac{\partial \theta_j}{\partial X_j}\right|_{X_j = 0} = N_{U,j} (\theta_{j+1,1} - \theta_{j,2}) = \left.\frac{\partial \theta_{j+1}}{\partial X_{j+1}}\right|_{X_{j+1} = 0} \tag{3.16}$$

$$\theta_j(1,T) = \theta_{j+1}(0,T) \tag{3.17}$$

The above m differential equations, eqns (3.12), and their 3m boundary conditions as given by eqns (3.13 to 17) could be solved simultaneously using Laplace transforms in a manner similar to that used in Chapter 2. This is done as follows.

3.2.2 LAPLACE TRANSFORMS

The Laplace transforms of eqns (3.12 to 17) are, respectively

$$\frac{d^2 \bar{\theta}_j}{dX_j^2} - p_j^2 \; \bar{\theta}_j = 0 \quad , \quad p_j = \sqrt{s/N_{F,j}} \tag{3.18}$$

$$- k_1 \frac{t_1}{\partial x_1}\Bigg|_{x_1=0} = \in I + h_o(t_a - t_{1,1}) \tag{3.3}$$

It should be remembered here that both the intensity of solar radiation I and the outside air temperature t_a are known periodic functions of τ ; and $t_{1,1}$ is the temperature of the outside surface. For the inside surface at $x_m = \ell_m$, conservation of energy gives

$$-k_m \frac{\partial t_m}{\partial x_m}\Bigg|_{x_m = \ell_m} = h_r(t_{m,2} - t_r) \tag{3.4}$$

Here $t_{m,2}$ is the temperature of the inside surface.

Where there are thermal contact resistances between the layers or, for that matter air spaces of negligible heat capacity, the temperatures would not be the same at the two sides of an interface. For example, the interface between the layers j and j+1, the temperature $t_{j,2}$ on the right hand side of layer j would not be the same as $t_{j+1,1}$ on the left hand surface of layer j+1. If the thermal contact resistance at this interface is denoted by its reciprocal, conductance U_j, we would have the remaining 2m-2 «coupling conditions» to denote the conservation of energy at these m-1 interfaces as

$$-k_j \frac{\partial t_j}{\partial x_j}\Bigg|_{x_j = \ell_j} = U_j(t_{j,2} - t_{j+1,1}) = -k_{j+1} \frac{\partial t_{j+1}}{\partial x_{j+1}}\Bigg|_{x_{j+1} = 0} \tag{3.5}$$

It should be noted that the above expression denotes two coupling conditions for this interface, hence eqns (3.5) give the required 2m-2 conditions.

Where there is no thermal contact resistance at an interface, say the one considered above, then

$$t_{j,2} = t_{j+1,1} \tag{3,6}$$

Since conductance U_j would then be infinite, the middle term of eqn (3.5) would be indeterminate and eqn (3.6) would replace the second relation of eqns (3.5).

3.2.1 DIMENSIONLESS FORM

The problem could be rendered dimensionless by the method used in the previous chapters, i.e., by using eqns (1.6, 7 and 15) with ℓ_j as the length criteria and defining

$$N_B = h_r \ \ell_1/k_1 \tag{3.7}$$

$$N_{F,j} = \alpha_j \ \tau_{cy}/\ell_j^2 \tag{3.8}$$ [1]

1. It should be noted that $N_F = N_k/N_B{}^2$. Fourier number is used in this chapter because Biot number N_B does not have its traditional meaning for an intermediate layer where its surfaces are not subjected to convection.

The space boundary conditions are as follows. For the outside surface at $x_1 = 0$:

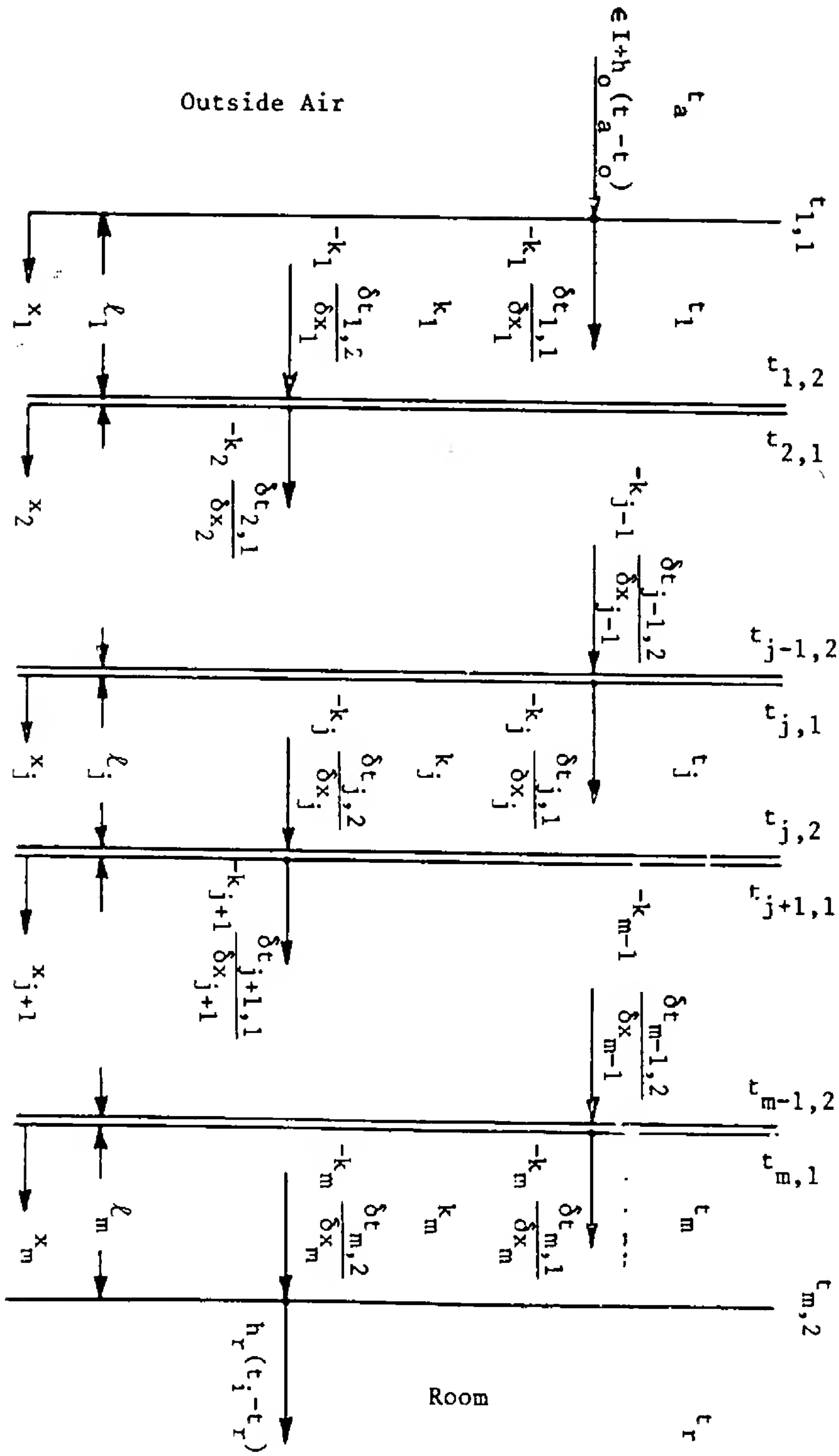


Fig 3.1

3.1 INTRODUCTION

In the previous chapter, the case of a simple building component, i.e., made of a single homogeneous material, was considered. However, most walls are composite and, in many cases, the above assumption would lead to considerable errors. Examples of such composite walls are ones with insulating layers, with thick plaster on one or both sides, etc.

In this chapter, a composite wall of m homogeneous layers is considered with periodic change of outside air temperature and insolation, and constant indoor temperature. The problem is formulated for the case where thermal contact resistances are present between the various layers. The method of solution is given, however, for the case where such resistances are absent. The problem is solved to give the thermal flux density through the inside wall surface. This solution provides a basis for the determination of the capacity of the refrigerating or air conditioning equipment, and the proper selection of wall layers.

Because of the slight difference between the present problem and that of the previous chapters, the problem is formulated anew in both dimensional and dimensionless forms. The method of solution, in essence, follows that used in the previous chapter.

3.2 ANALYSIS

Consider a composite wall of m homogeneous layers: 1,2,3,..., j, j+1,..., m as shown in Fig. 3.1. Each layer has a thickness l_j and properties k_j, c_j, ρ_j and $\alpha_j = k_j/\rho_j c_j$ where j = 1,2, ...m. The local distance x_j is measured from the left hand side surface (towards the outside air) designated by subscript «j,1».

For each layer, the governing relation is the general conduction equation in one-dimension, i.e.

$$\frac{\partial^2 t_j}{\partial x_j^2} = \frac{1}{\alpha_j} \frac{\partial t_j}{\partial \tau} \tag{3.1}$$

There are m of these equations that need 2m «space boundary conditions» and m «time conditions»; the latter ones are simply those of periodicity for established-state conditions, i.e., as eqn (1.2),

$$t_j(x_j, \tau) = t_j(x_j, \tau + M\tau_{cy}) \qquad M=1, 2,... \tag{3.2}$$

Chapter 3

THERMAL BEHAVIOUR
OF
COMPOSITE BUILDING COMPONENTS

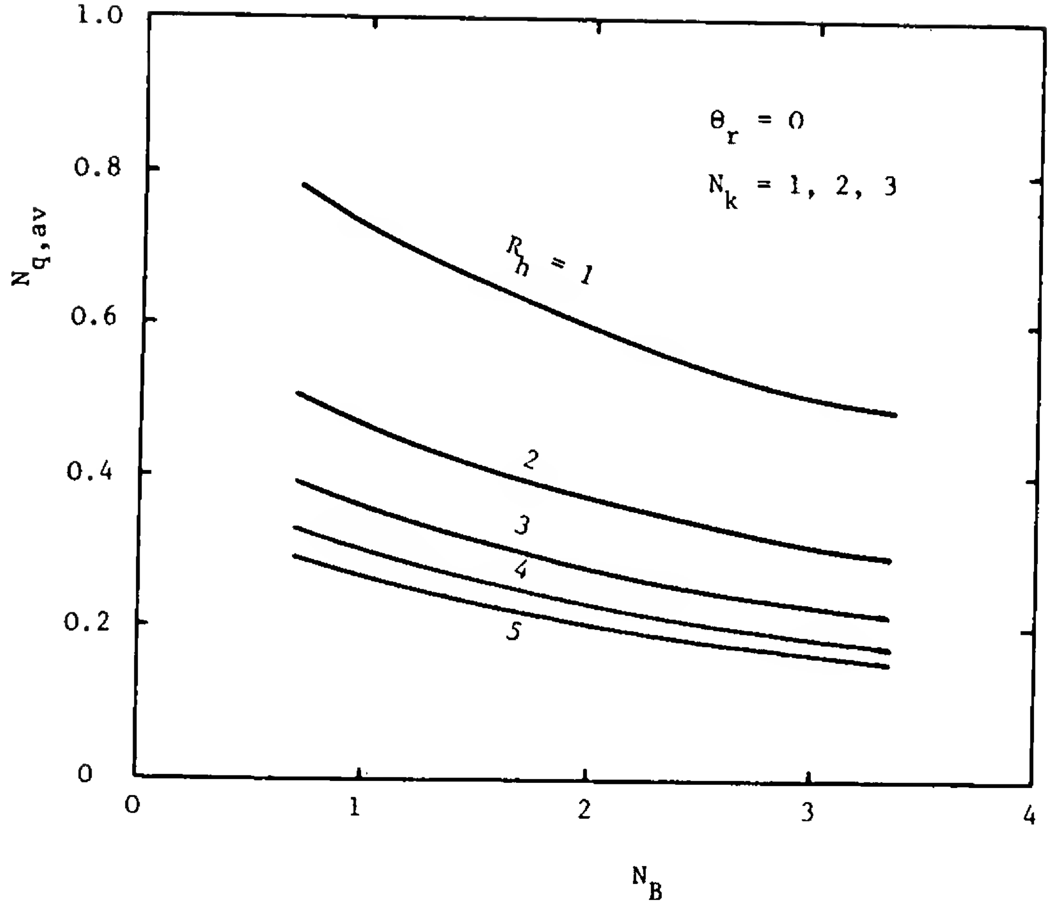


Fig. 2.6

2.5 CONCLUSIONS

A more general method for the determination of the thermal behaviour of buildings is presented. Generality is obtained through the use of dimensionless groups, and the normalization of meteorological data. Generality is also attained by analysing the periodic meteorological functions to their harmonics, and giving a solution for a general harmonic. This solution is obtained mathematically by the «frequency response» method; is general and could be used directly for any situation. The final solution for a given general case could be obtained by the superposition of the various harmonics, and of a mean steady-state solution.

An example is solved for the case of a south facade which is practically equivalent, except for the magnitude of solar irradiance, to the case of a roof.

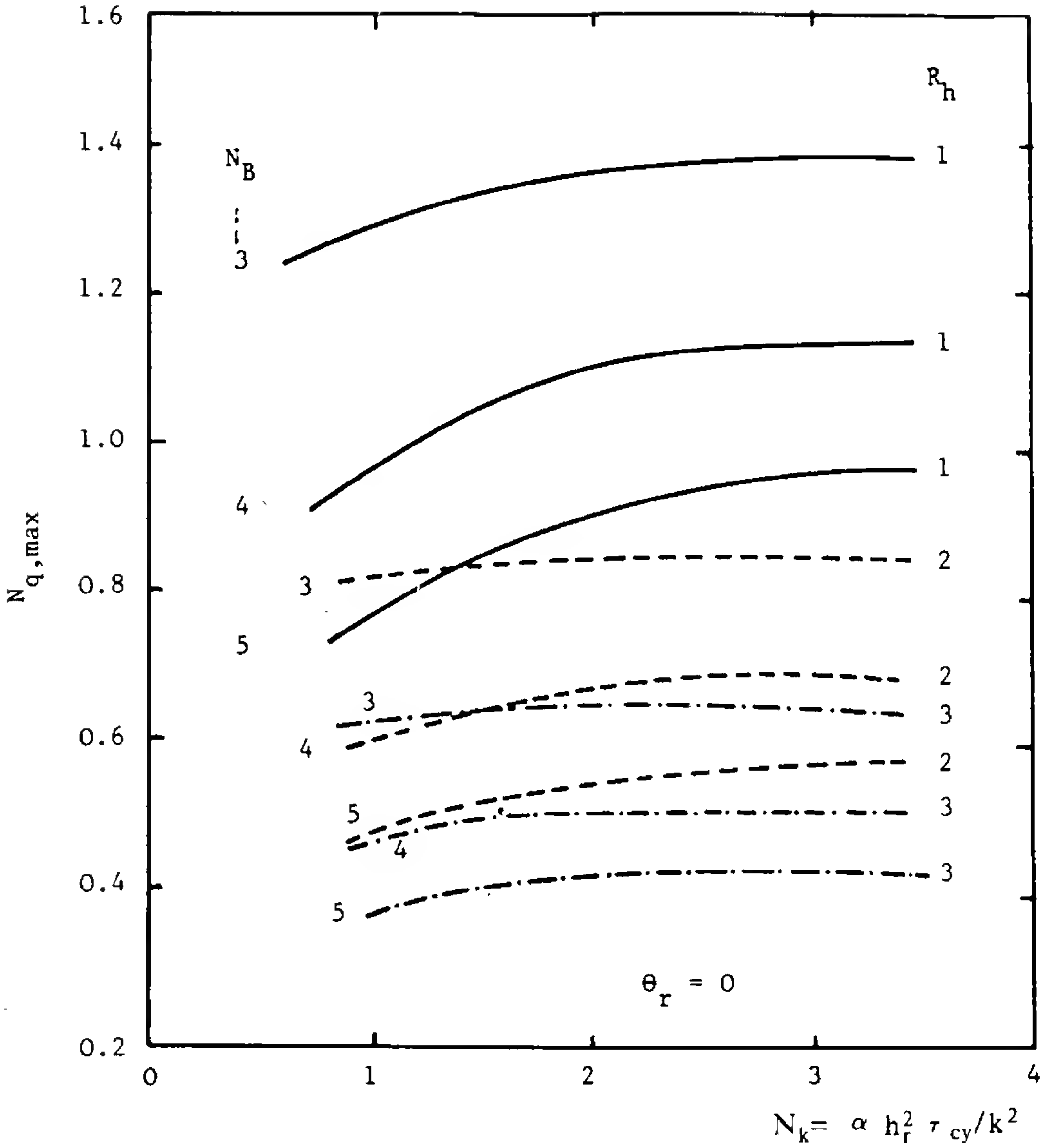

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1
2
3
4
$N_{q,max}$
$N_k = \alpha\ h_r^2\ \tau_{cy}/k^2$
N_B
R_h
$\theta_r = 0$
3
4
5
3
3
4
5
4
5
1
1
1
2
2
3
2
3
3

Fig.2.5

The effect of the conductivity parameter N_k on the heat flux is shown in Fig. 2.4; its increase by, say, decreasing k c increases the heat flux to the room due to the decrease in the walls heat capacity. This also results in advancing, time wise, the maximum flux.

Figure 2.5 shows a plot of the maximum heat flux $N_{q,max}$ versus N_k for various values of N_B and R_h. The importance of this maximum flux is that it determines the capacity of the refrigeration or air conditioning unit. The effect of N_k on $N_{q,max}$ is not large, its increase increases $N_{q,max}$ rather slightly. However, an increase in either N_B or R_h decreases $N_{q,max}$ appreciably. The effect of the former means an increase in the room's heat transfer coefficient, hence effective dissipation of the flux that flattens out the energy-time curve; it may also mean an increase in the wall thickness l or a decrease in the thermal conductivity k, either means an increase in the thermal resistance. On the other hand, an increase in R_h means an increase in the outside heat transfer coefficient and, hence, better dissipation of heat to the outside air; naturally, this decreases $N_{q,max}$.

The average reduced flux $N_{q,av}$ determines the energy consumption; its relation to N_B, N_k and R_h are shown in Fig. 2.6. The effect of N_k is negligibly small; as mentioned above, its change flattens the time distribution of flux without affecting its mean value to any considerable degree. An increase in either N_B or R_h decreases $N_{q,av}$ for the reasons outlined in connection with $N_{q,max}$.

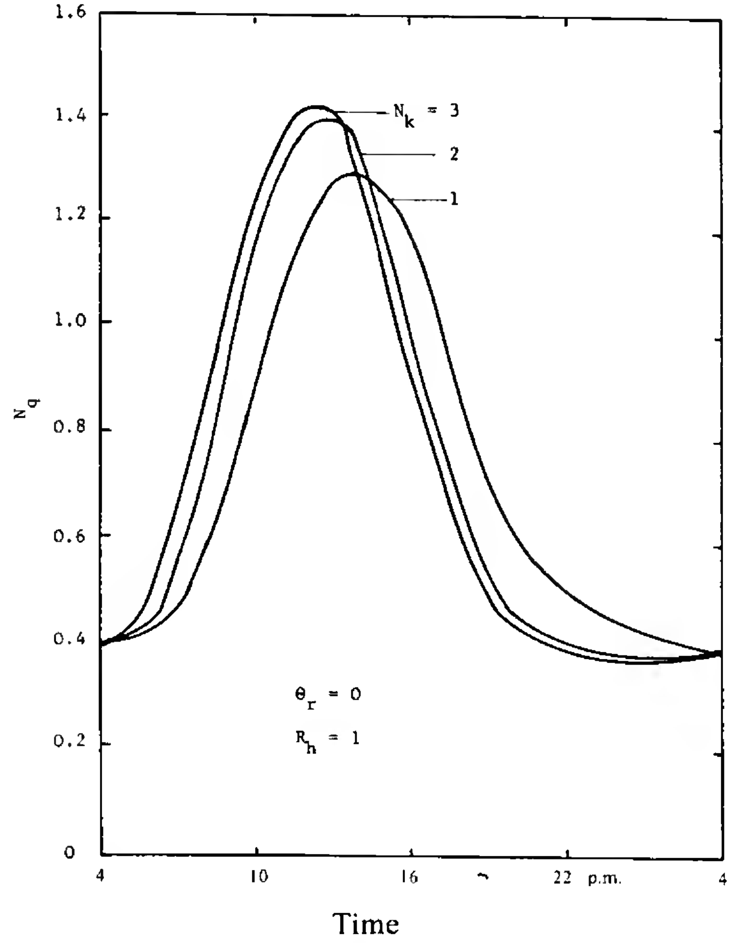


Fig. 2.4

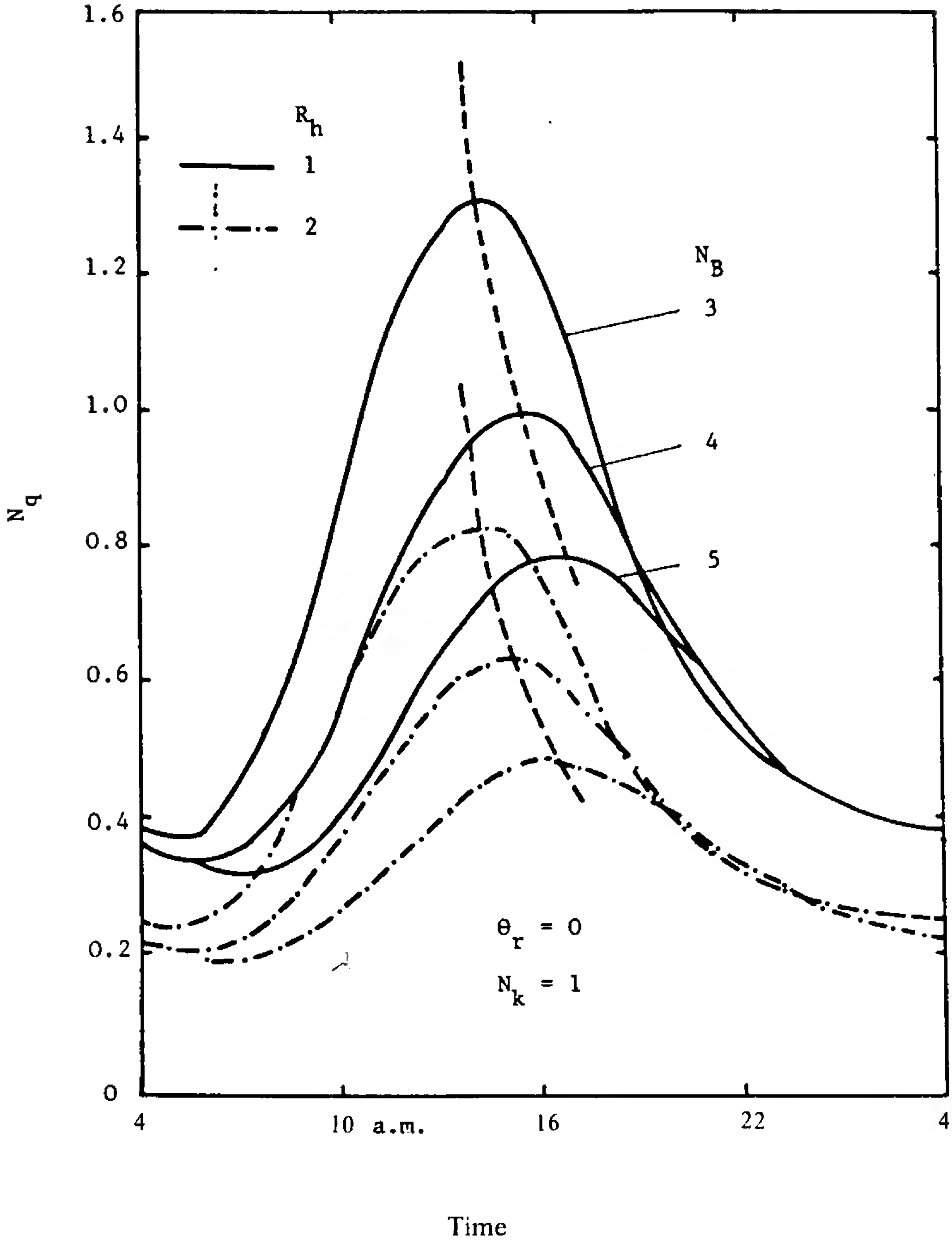

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
R_h
1
2
N_B
3
4
5
N_q
$\theta_r = 0$
$N_k = 1$
4
10 a.m.
16
22
4
Time

Fig. 2.3

south facade, and for an east wall in a haze-free atmosphere; their data are also shown in Fig. 2.1. The tables and figure represent, quite closely, the data published by ASHRAE [1]. Admittedly, these data merit a wider study than has been possible so far. Efforts should be made to standardize these normalized values of θ_a and R_I; values for the latter should be determined for different orientations and weather conditions.

Using hourly values from the above mentioned tables, each was represented by 24 terms of Fourier series, including the «zero term». Using the calculated Fourier coefficients, given also in Tables A.1 to 3, hourly values of N_q were comuted; the results are shown in Fig. 2.2 for R_h = 1 and 2, and for N_B = 3, 6 and 9. As could be seen, an increase in N_B decreases the maximum flux density and retards it. On the other hand, an increase in R_h decreases the maximum flux density without affecting its time.

Figure 2.3 shows the effect of N_B for a given value of N_k. A larger Biot number means, for given h_r and k, an increase in the thickness . As shown in the figure, this reduces the average and maximum heat fluxes and retards the time of the latter. Figure 2.3 shows also that the effect of the ratio R_h is the same as given by Fig. 2.2; it does not have any significant effect on the time of the maximum load.

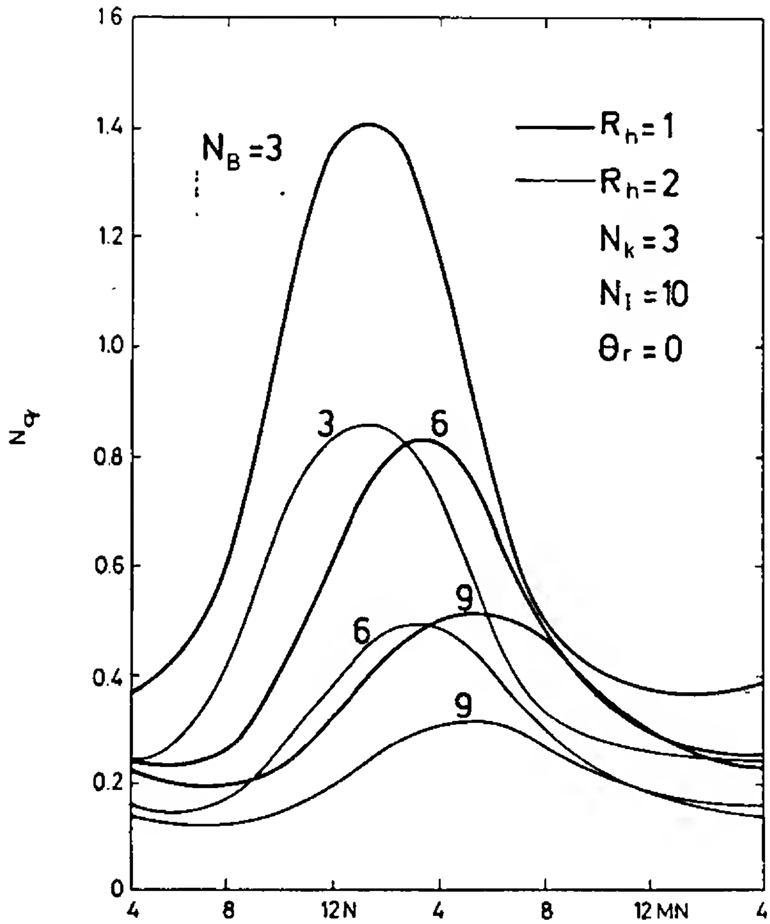


Fig 2.2

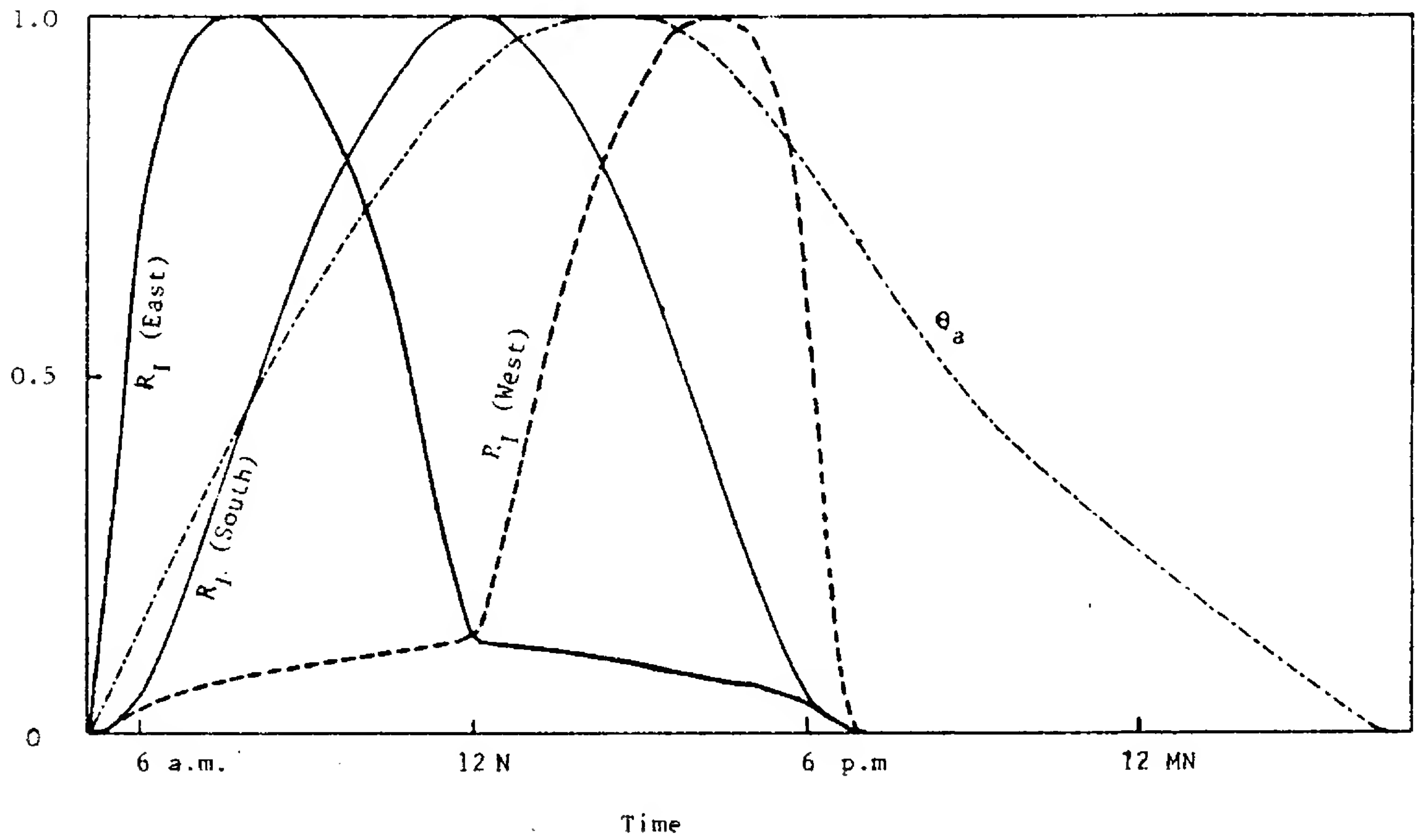


Fig. 2.1

Therefore, the contribution of the nth harmonic driving function of eqn (2.14) to the heat flux density into the room is given by

$$N_{q,l,n} = \sqrt{2}\, N_B\, N_l \quad \gamma_n\, R_{l,n} \cos\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right) / r_n$$

The sine part of eqn (2.8) has the same effect as the cosine part above. The contribution of all the radiative harmonics to the heat flux density is obtained by superposition as

$$N_{q,l} = \sqrt{2}\, N_B\, N_l \sum_{n=1}^{m} (\gamma_n/r_n)\Big[R_{l,c,n} \cos\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)$$

$$+ R_{l,s,n} \sin\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)\Big] \qquad (2.38)$$

In a similar manner; the contribution of all the «outside air temperature harmonics» is given by

$$N_{q,\Theta} = \sqrt{2}\, N_B\, R_h \sum_{n=1}^{m} (\gamma_n/r_n)\Big[\Theta_{a,c,n} \cos\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)$$

$$+ \Theta_{a,s,n} \sin\left(2n\pi\, T + \phi_n + \frac{\pi}{4}\right)\Big] \qquad (2.39)$$

2.3.2.4 *Total Flux Density:* The total flux density is obtained by adding the steady and established parts of eqns (2.12, 38 and 39)

$$N_q = \frac{R_h(\Theta_{a,0} - \Theta_r) + N_l\, R_{l,0}}{1 + R_h\,(1 + N_B)}$$

$$+ \sqrt{2} N_B\, N_l \sum (\gamma_n/r_n)\Big[R_{l,c,n} \cos\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)$$

$$+ R_{l,c,n} \sin\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)\Big]$$

$$+ \sqrt{2} N_B\, R_h \sum (\gamma_n/r_n)\Big[\Theta_{a,c,n} \cos\left(2n\pi T + \phi_n - \frac{\pi}{4}\right)$$

$$+ \Theta_{a,c,n} \sin\left(2n\pi\, T + \phi_n - \frac{\pi}{4}\right)\Big] \qquad (2.40)$$

2.4 NUMERICAL EXAMPLE

In the following, the results obtained by the previous analysis for a roof or a southern wall are presented. For this purpose, the dimensionless functions Θ_a and R_l should be known. A study of meteorological data for the summer months of a number of cities in the temperate zone[1] showed that Θ_a follows closely the values given in Table A.1 of Appendix A and shown graphically in Fig. 2.1. Tables A.2 and 3 give R_l for a roof or a

---

1. Values for Θ_a were averaged from meteoroligical data from various stations in Egypt, Sudan and the Southwest region of U.S.A. They also agree with the data given by Threlkeld [3] Fig. 14.17.

$$N_{q,I,n,amp} = R_{I,n} \left| \overline{H}_{I,n}(2n\pi i) \right| \tag{2.25}$$

The phase shift, ψ is also obtained as the argument of the same transfer function, i.e.,

$$\psi_{I,n} = \arg \overline{H}_{I,n}(2n\pi i) \tag{2.26}$$

To implement this method for the nth harmonic of the radiative part, the following process is used.

$$\overline{H}_{I,n}(2n\pi i) = N_B N_I\, p(2n\pi i) / \overline{F}(2n\pi i) \tag{2.27}$$

From the theory of complex variables, eqn (2.20) gives

$$p(2n\pi i) = \gamma_n (1 + i) = \sqrt{2}\, \gamma_n \exp(i\pi/4) \tag{2.28}$$

where

$$\gamma_n = N_B \sqrt{n\pi / N_k} \tag{2.29}$$

Using the relations
sinh(y + iz) = cos z sinh y + i sin z cosh y
cosh(y + iz) = cos z cosh y + i sin z sinh y,
the function F(2n π i) is determined as

$$\overline{F}(2n\pi i) = P_n + i Q_n = r_n \exp(i\phi_n) \tag{2.30}$$

where

$$P_n = N_B^2 R_h \cos\gamma_n \sinh\gamma_n - 2\gamma_n^2 \sin\gamma_n \cosh\gamma_n$$
$$+ N_B(1 + R_h)\gamma_n(\cos\gamma_n \cosh\gamma_n - \sin\gamma_n \sinh\gamma_n) \tag{2.31}$$

$$Q_n = N_B^2 R_h \sin\gamma_n \cosh\gamma_n + 2\gamma_n^2 \cos\gamma_n \sinh\gamma_n$$
$$+ N_B(1 + R_h)\gamma_n(\cos\gamma_n \cosh\gamma_n + \sin\gamma_n \sinh\gamma_n) \tag{2.32}$$

$$r_n = \sqrt{P_n^2 + Q_n^2} \tag{2.33}$$

$$\phi_n = \arctan(Q_n / P_n) \tag{2.34}$$

Substituting from eqns (2.28 and 33) into eqn (2.27)

$$H_{I,n}(2n\pi i) = \sqrt{2} N_B N_I \gamma_n \exp i\left(\frac{\pi}{4} - \phi_n\right) / r_n \tag{2.35}$$

Using this relation in eqns (2.25 and 26) gives

$$N_{q,I,n,amp} = \sqrt{2} N_B N_I R_{I,n} \gamma_n / r_n \tag{2.36}$$

and

$$\psi_n = \frac{\pi}{4} - \phi_n \tag{2.37}$$

$$\left.\frac{d\bar{\Theta}}{dX}\right|_{X=1} = N_B\left(\bar{\Theta}_r - \bar{\Theta}\Big|_{X=1}\right) \tag{2.17}$$

$$\bar{N}_{q,n} = \bar{\Theta}\Big|_{X=1} - \bar{\Theta}_r \tag{2.18}$$

The solution of the boundary value problem given by eqns (2.15 and 17) is:

$$\begin{aligned}\bar{\Theta} = \Big\{ & N_B\,(p \cosh pX + N_B R_h \sinh pX)\ \bar{\Theta}_r \\ & + N_B R_h\,[p \cosh p(1-X) + N_B \sinh p(1-X)]\ \bar{\Theta}_a \\ & + N_B N_I\,[p \cosh p(1-X) + N_B \sinh p(1-X)]\,\bar{R}_I \Big\} \Big/ \bar{F}(s)\end{aligned} \tag{2.19}$$

In this expression

$$p = p(s) = N_B \sqrt{s/N_k} \tag{2.20}$$

$$\bar{F}(s) = (p2 + N_B^2 R_h)\sinh p + p\,N_B\,(1 + R_h)\cosh p \tag{2.21}$$

The transformed reduced flux density could now be obtained from eqn (2.18) using eqns (2.19 and 21), it gives

$$\begin{aligned}\bar{N}_{q,n} = \frac{p(s)}{\bar{F}(s)}\ & [N_B R_h\ \bar{\Theta}_a + N_B N_I R_I \\ & - (p \sinh p + N_B R_h \cosh p)\ \bar{\Theta}_r]\end{aligned} \tag{2.22}$$

2.3.2.2 *Transfer Function:* A transfer function H(s) is the ratio between the Laplace transforms of the dependent and driving functions. In the present case there are two driving functions as given by eqns (2.13 and 14). Their effects appear as the first two terms of eqn (2.22). The third term gives the effect of the room air temperature, a constant in the present problem, and was handled in the steady-state part.

The transfer function for the nth harmonic of the radiative part is obtained as follows

$$\bar{H}_{I,n}(s) = \bar{N}_{q,I,n} / \bar{R}_{I,n} = N_B N_I\, p(s)/\bar{F}(s) \tag{2.23}$$

For the outside air temperature part

$$\bar{H}_{\Theta,n}(s) = \bar{N}_{q,\Theta,n} / \bar{\Theta}_{a,n} = N_B R_h\, p(s)/\bar{F}(s) \tag{2.24}$$

2.3.2.3 *Established-State Solution:* In the frequency response method [16], the amplitude of the dependent function is obtained by multiplying the amplitude of the excitation function by the modulus of the corresponding transfer function in which the Laplace transform variable s is replaced, in this case, by $2n\pi$ i. Hence, for the radiative part for example, the amplitude of the nth harmonic is given by:

harmonic, itself a harmonic function that gives fluctuations about the steady mean. The final solution for the original periodic function could then be obtained by superposition

2.3.1 STEADY-STATE PART

For this part, the temperature is independent of time, eqns (2.1) to (2.4) reduce to, respectively

$$\frac{d^2\Theta}{dX^2} = 0 \qquad \text{or} \qquad \frac{d\Theta}{dX} = \text{const.} \tag{2.9}$$

$$\Theta = \Theta(X)$$

$$-\frac{d\Theta}{dX} = \Theta_o - \Theta_i = N_B R_h(\Theta_{a,o} - \Theta_o) + N_B N_l R_l \tag{2.10}$$

$$= N_B(\Theta_i - \Theta_r) \tag{2.11}$$

Solving for Θ_o and Θ_i in the last two equations and substituting into eqn (2.6) gives

$$N_{q,o} = \frac{R_h(\Theta_{a,o} - \Theta_r) + N_l R_{l,O}}{1 + R_h(1 + N_B)} \tag{2.12}$$

The first term on the right hand side gives the effect of the outside air temperature; the second term gives the effect of solar radiation. Indeed, eqn (2.12) gives the mean load on the air conditioning unit during the day.

2.3.2 HARMONICS PART

Noting that a sine function is a cosine function with a phase shift, the method outlined above is implemented here by considering a single harmonic for Θ_a and R_l in eqn (2.3)

$$\Theta_a = \Theta_{a,n}\cos(2n\pi T) \tag{2.13}$$

$$R_l = R_{l,n}\cos(2n\pi T) \tag{2.14}$$

In the «frequency response» method [16], the transfer function as obtained from the Laplace transform of the problem would be used. The transfer function is used to give the amplitude of the established-state solution and its phase shift from the driving function as follows.

2.3.2.1 *Laplace Transformation:* Equations (2.1, 3, 4 and 6) when transformed in the usual manner give, respectively

$$\frac{d^2\bar{\Theta}}{dX^2} - \frac{N_B^2}{N_k} s\bar{\Theta} = 0 \tag{2.15}$$

$$\left.\frac{d\bar{\Theta}}{dX}\right|_{X=0} = N_B R_h\left(\bar{\Theta}\Big|_{X=0} - \bar{\Theta}_a\right) - N_B N_l \bar{R}_l \tag{2.16}$$

$$\left.\frac{\partial \Theta}{\partial X}\right|_{X=0} = N_B R_h (\Theta_0 - \Theta_a) - N_B N_I R_I \tag{2.4}$$

$$\left.\frac{\partial \Theta}{\partial X}\right|_{X=1} = N_B (\Theta_r - \Theta_i) \tag{2.3}$$

$$\Theta_i - \Theta_r = N'_w \frac{d\Theta_r}{dT} + N''_{q,i} \tag{2.5}$$

The case of uncontrolled room temperature without internal heat load ($N'_{q,i} = 0$) was solved before by finite differences. In the present work, the case of an air conditioned space is treated. In this case Θ_r is a constant and, therefore, $d\Theta_r/dT = 0$. Equation (2.5) reduces to

$$\Theta_i - \Theta_r = N_q \tag{2.6}$$

In this relation and the following discussions, the double prime and the i-subscript are removed to simplify the notations.

2.3 SOLUTION

The problem, as formulated above, is to be solved for $N_q = N_q$ (T), a periodic function. It should be noted that, in these equations, Θ_a and R_I are periodic functions of time only and independent of position X.

In the method presented here, Θ_a and R_I are analysed to their various harmonics by practical Fourier analysis [15], i.e.,

$$\Theta_a = \Theta_{a,0} + \sum_{n=1}^{m} [\Theta_{a,c,n} \cos(2n\pi T) + \Theta_{a,s,n} \sin(2n\pi T)] \tag{2.7}$$

and

$$R_I = R_{I,0} + \sum_{n=1}^{m} [R_{I,c,n} \cos(2n\pi T) + R_{I,s,b} \sin(2n\pi T)] \tag{2.8}$$

Each of eqns (2.7 and 8) contains a constant term, subscripted O, and a series of harmonics. The constant term, from Fourier analysis, is the factor for n = 0 and represents the integrated mean of the function, whereas the harmonics represent fluctuations about this mean. The solution for the constant term is, naturally, a steady-state solution. It gives for eqn (2.7) a steady conduction flux density that is due to the difference between the mean outside air temperature and the room temperature. For eqn (2.8), the constant term gives the steady conduction flux density due to the mean solar irradiance if falling steadily on the wall.

A solution for a general harmonic n gives the reduced flux density $N_{q,n}$ for this

2.1 INTRODUCTION

In this chapter, the thermal behaviour of a simple building component (wall, roof, etc.) and its effect on the indoor conditions are treated analytically. The mathematical formulation of the problem in Chapter 1 is used here, simplified to the one-dimentional case. The problem is stated and solved in terms of dimensionless groups. This renders the solution more general. Indeed, a single solution could be used for a broad range of conditions: materials, latitudes, etc.

Further, the effect of outside air temperature and of solar radiation are separated, and the solution gives their separate effects. Because the effect of the outside air temperature is the same for all orientations, this adds to the flexibility and generality of the solution. The problem treated here is that of controlled indoor temperature; i.e., for a refrigerated or air conditioned space.

The method of solution used is purely mathematical. The dimensionless peiodic driving functions are analysed to their harmonics, where steady-state terms also appear. The solution of the steady-state parts are straightforward, and give the average load on the air conditioning unit; hence indicate directly the total energy needed per cycle (day). The solutions for a single general harmonic is obtained by the «frequency response» method used by the authors in another kind of problem [14]. This general harmonic solution could be used directly for other special situations that may not fall under a general case.

With the effects of the steady-state terms, and of each harmonic determined, the final solution for a given general situation is obtained by simple superposition.

2.2 FORMULATION

The problem is formulated here in the manner outlined above. For the one-dimensional case with no external heat generation ($q'_0=0$), uniform inside heat transfer coefficient ($R_{h,r} = 1$) and the dimensionless groups as defined by eqns (1.8, 9, 10, 11-a, 13-a, 14 and 15), and eqns (116) to (120) become

$$\frac{\partial^2 \Theta}{\partial X^2} = \frac{N_B^2}{N_k} \frac{\partial \Theta}{\partial T} \tag{2.1}$$

$$\Theta(X,T) = \Theta(X,T+n) \quad n = 1,2,3,... \tag{2.2}$$

Chapter 2

THERMAL BEHAVIOUR OF SIMPLE BUILDING COMPONENTS

The contents of this chapter were presented at the ICHMT Seminar on Heat and Mass Transfer in Buildings [8].

1.3.5 MODEL SCALE

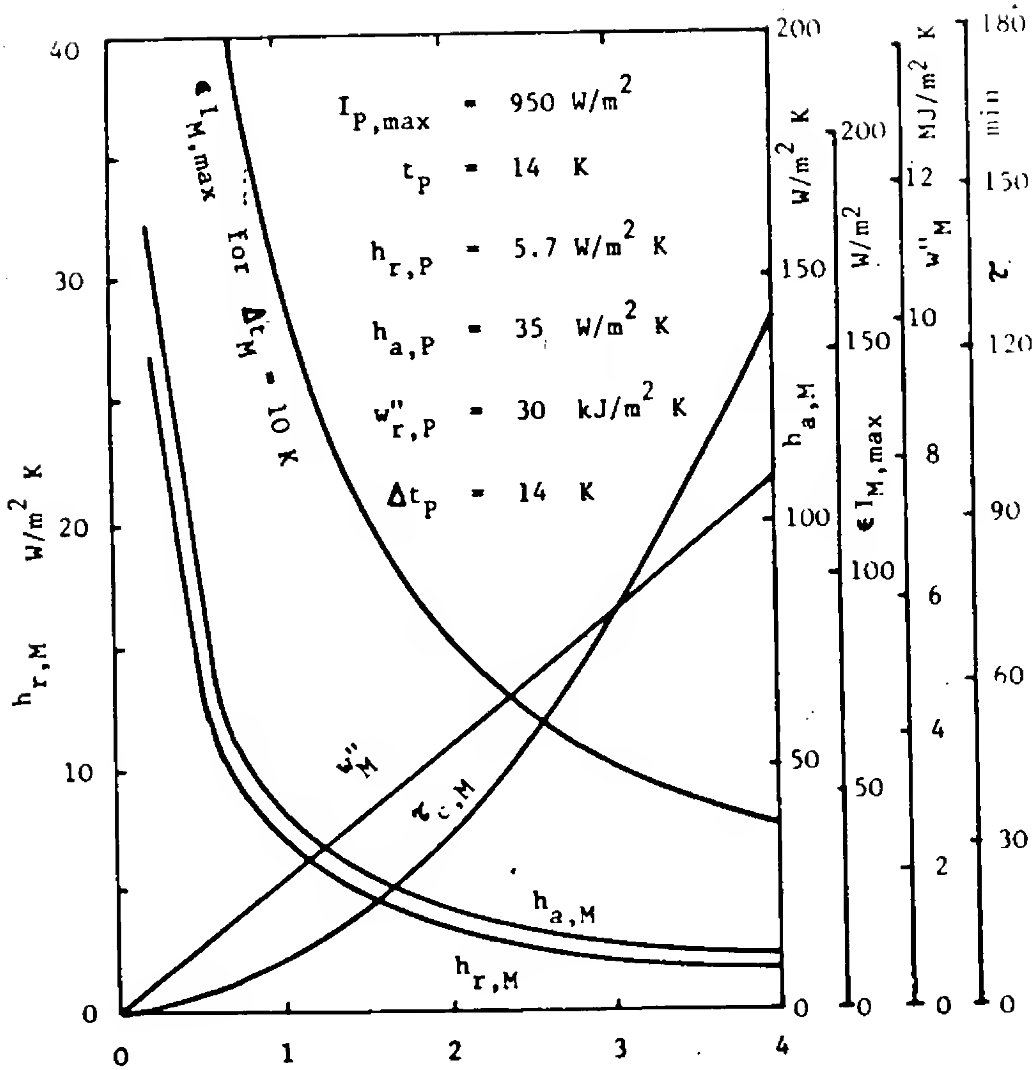
In modeling a complete building, it is not necessary to use a single scale for the wall thickness and the overall model size. In general, this means that it is possible to use two length criteria, L_w for the wall material and L_B for the whole building. The use of the prorated values w''_r and q''_i makes it much easier as the length criterion does not appear in eqns (1.11-a) and (1.13-a).

With the use of two scales, a large scale may be used to model the building components (walls, roofs, etc.) to obtain the desirable conditions outlined above and shown in Fig. 1.1. Another scale would be used for the general building or room size to make a reasonably small simulation facility possible. This scale is the one that determines the overall model room heat capacity $w_{r,M}$ and heat load $q_{i,M}$.

It should be noted that the two scales are reasonably independent. Any two scales could be used as long as the difference between them would not distrort the two – or three – dimensional effects at corners, etc.

1.4 CONCLUSIONS

The mathematical relations that control the thermal behaviour of a building are stated in a most general form. The similarity groups that govern simulation by a physical model are obtained from these relations as dimensionless parameters; they are chosen so as to separate the effects of the dimensional parameters. These groups are studied in some detail to show how the scale of the model and its material could be determined. It is shown that it is possible, at least in some cases, to use two scales for the model: one for the building itself, the other for its components.



Model wall thickness, cm

Simulation of a 15-cm Brick Wall by Cork Board

Fig. 1.1

$$q_{i,M} = K_{q,i}\, I_{M,max}\, L_M^2 \qquad (1.28)$$

This shows that the internal heat load should be proportional to the product $I_{M,max} L_M^2$

1.3.3 GENERAL REMARKS ON THE CHOICE OF MATERIAL

Summing up the above results, the use of a model material with low thermal conductivity k_M allows the use of a thin model wall, L_M; it also allows the use of small values of $h_{r,M}$, $\overline{h}_{a,M}$, $I_{M,max}$ and temperature span Δt_M. For a given heat capacity $(\rho c)_M$, a low value of k_M allows the use of a reasonably short period $\tau_{cy,M}$. All these are desirable operating conditions that indicate the use of an insulating material for the model.

On the other hand, for a given thermal conductivity k_M, a high heat capacity $(\rho c)_M$ (or low thermal diffusivity α_M), gives a longer period $\tau_{cy,M}$, and requires a high value of the room's water equivalent $w_{r,M}$ which could be controlled by the general model size (not its wall thickness). It, therefore, seems that a suitable modeling material is an insulator with a relatively high heat capacity.

If a certain material is chosen for the model, a very thin wall (small L_M) gives high values of $h_{r,M}$, $\overline{h}_{a,M}$ and $I_{M,max}$, low values of the temperature span Δt_M, and very low values of the operating period $\tau_{cy,M}$. These are in general not desirable. To show the effect of the model wall thickness L_M, Fig. 1.1 was calculated for a brick wall thickness 150 mm thick modeled by various thicknesses of cork board. In the figure, the water equivalent w_r of the room is prorated to a unit area of the inside surface rather than to the square of the length criterion L^2. This is more convenient for the experimental study. Consequently,

$$w''_r = w_r / A_r \qquad (1.29)$$

It seems from the figure that modeling is feasible with a model wall thickness of 10 to 30 mm.

1.3.4 MODELING BUILDING INTERIOR

In modeling a complete building, it would be very difficult to simulate completely the conditions inside the room. This merits the use of a constant room heat transfer coefficient $\overline{h}_r$ and prorated water equivalent w''_r as mentioned before. For the same reason, the internal load q_i may also be prorated to a unit area of the inside wall surface, hence q''_i would be used rather than q_i such that

$$q''_i = q_i / A_r \qquad (1.30)$$

With the definitions of eqns (1.29) and (1.30), the pertinent dimensionless groups N_w and N_q may be redefined as follows:

$$N''_w = w''_r / \overline{h}_r\, \tau_{cy} \qquad (1.11\text{-a})$$

$$N''_{qi} = q''_i / \overline{h}_r\, \Delta t \qquad (1.13\text{-a})$$

This would also simplify the form of eqn (1.20) to

$$\Theta_i - \Theta_r = N''_w \frac{\partial \Theta_r}{\partial T} + N''_{qi}. \qquad (1.20\text{-a})$$

properties. In the following discussion, the K's are constants subscripted to indicate where relevant.

The heat transfer coefficient $\bar{h}_{r,M}$ is given by eqn (1.8) as

$$\bar{h}_{r,M} = N_B\, k_M/L_M = K_{h,r}\, k_M/L_M \tag{1.22}$$

This expression shows that once $h_{r,M}$ is chosen, a low value of k_M allows the use of a thin model wall.

The outside heat transfer coefficient $h_{a,M}$ is related to the indoors heat transfer coefficient $\bar{h}_{r,M}$ through eqn (1.14) that give with eqn (1.22)

$$h_{a,M} = R_h\, h_{r,M} = K_{h,a}\, k_M/L_M \tag{1.23}$$

The similarity between eqns (1.22) and (1.23) shows that $h_{a,M}$ is affected in the same way as $h_{r,M}$.

Simulated solar intensity and temperature span are related to the thermal properties of the model material through eqn (1.9); it gives with eqn (1.22)

$$I_{M,max} / \Delta\, t_M = N_I\, \bar{h}_{r,M} = K_I\, k_M/L_M \tag{1.24}$$

The similarity between eqns (1.22) and (1.24) is, again, clear. However, eqn (1.24) shows that for a given temperature span, a low thermal conductivity allows the use of a low radiation intensity. Alternatively, for a given radiation source, a low value of k_M allows the use of a large temperature span for the model; this leads to more accurate temperature measurements.

The cyclic period $\tau_{cy,M}$ of the model is related to the model's thermal properties through eqn (1.10) which gives, with eqn (1.22)

$$\tau_{cy,M} = N_k\, k_M^2 \,/\, \alpha_M\, \bar{h}_{r,M}^2 = K_\tau\, L_M^2 / \alpha_M$$

$$= K_\tau\, L_M^2\, (\varrho\, c)_M \,/\, k_M \tag{1.25}$$

This relation shows that for a given model thickness L_M, a low value of α_M gives a longer period $\tau_{cy,M}$. Further, since $\alpha_M = k_M \,/\, (\varrho\, c)_M$, for a given value of k_M, a low heat capacity $(\varrho\, c)_M$ of the model material is required to reduce the time period.

Equation (1.11) correlates the water equivalent $w_{r,M}$ to the model properties, it gives with eqns (1.22) and (1.25)

$$w_{r,M} = N_w\, \bar{h}_{r,M}\, \tau_{cy,M}\, L_M = K_w\, (\varrho\, c)_M\, L_M^3 \tag{1.26}$$

Here the thermal conductivity of the model material does not affect the choice of $w_{r,M}$, only the heat capacity $(\varrho\, c)_M$ does. For a given L_M, as $(\varrho\, c)_M$ decreases, the heat capacity $w_{r,M}$ of the model interior should decrease.

As to the flux density $q''_{o,M}$, the relation effective in this case is eqn (1.12); it gives with eqns (1.22) and (1.24)

$$q''_{o,M} = K_{q,o}\, I_{M,max} \tag{1.27}$$

This shows that $q''_{o,M}$ should be proportional to the modeled insolation. In the same manner

$$\nabla\,\Theta.\,\overline{N}_r = N_B R_{h,r}(\Theta_i - \Theta_r) \tag{1.19}$$

$$\int_{S_i} R_{h,r}(\Theta_i - \Theta_r)\,dS_i = N_{q,i} + N_w \frac{\partial \Theta_r}{\partial T} \tag{1.20}$$

The derivatives in the above equations are with respect to the dimensionless X_j. The dimensionless inside surface area is given by

$$S_i = A_i/L^2 \tag{1.21}$$

The above formulation, eqns (1.16) to (1.20), is the general statement for two important problems. The first is the case of uncontrolled indoor temperature, as in passively controlled buildings. In this case, the internal heat load N_q should be known, and the problem would be solved for Θ_r. This was carried out for the one-dimensional case by Hassan and Hanna [4]. The second problem is for positively controlled indoor temperature, as in a cold store or an air conditioned building. In this case Θ_r is known, usually a constant, and the problem is solved for N_q. This is solved in the following chapter for the one-dimensional case, using the frequency response method.

1.3 SIMULATION

The analytic solutions referred to above are very useful for the prediction of the effect of a building component on the thermal behaviour of a building. However, this could be done only when the component is homogeneous[1] and of simple geometric shape. Still there are important cases which would not lend themselves to a mathematical solution. Examples are complete walls where heat is conducted in two or three dimensions, walls with air spaces or shading devices and, of course, the complex cases of complete buildings with intricate parts like towers, domes, etc., or where shadows are cast by other parts of the same structure, or by near-by buildings.

1.3.1 SIMULATION CONDITIONS

It is evident from the above that, to predict the thermal behaviour of a building, it is possible (and sometimes necessary) to determine this behaviour from measurements made on a scale model. This model must satisfy the similarity criteria defined by eqns (1.8) to (1.13), and should be tested under conditions of irradiation and surroundings that have the same functional relationships with the reduced time T as the prototype.

To simplify the problem of simulation, it seems reasonable that $h_r = \overline{h}_r$ = constant. This renders $R_{h,r} = 1$. Indeed, inside a building with proper air circulation, h_r is virtually constant, independent of time or locality on wall, floor, or ceiling.

1.3.2 CHOICE OF MODEL MATERIAL

The prototype exposed to a given set of weather conditions has a fixed set of values of the parameters defined by eqns (1.8) to (1.15), namely: N_B, R_h, N_l, N_k, N_w, N_q and R_l. The values of these parameters should be the same for both the prototype and the model. The operating conditions and dimensions of the model depend largely on its thermal

1. Homogeneity could be assumed without much error for the more important wall constructions. Properties of mortar are very nearly those of bricks in a brick wall, and gravel's properties are not very different from those of cement in a concrete wall.

1.2.1 SIMILARITY GROUPS

The general problem stated by eqns (1.1) to (1.5) could be rendered dimensionless by the following choice of variables. The independent variables are rendered dimensionless by referring distances to a length criterion L, and time to the period τ_{cy}, hence

$$X_j = x_j/L \qquad \text{and} \qquad T = \tau / \tau_{cy} \tag{1.6}$$

The temperature is reduced by referring its varation from a certain minimum temperature, say $t_{a,min}$ of the outside air, to the outside air temperature span $\Delta t = t_{a,max} - t_{a,min}$, hence

$$\Theta = \Theta\ (X_j,T) = (t - t_{a,min})/\ \Delta t \tag{1.7}$$

The dimensionless parameters are chosen so as to separate the effects of the various dimensional parameters. To achieve this, the parameters are referred to the length and time criteria L and τ_{cy}, the temperature span and the constant properties k and α. Further, the parameters are referred to the day's maximum insolation I_{max}, say on a surface normal to the sun rays; and to an internal coefficient of heat transfer $\bar{h}_r$.

The dimensionless parameters thus obtained are

$$N_B = \bar{h}_r L/k \tag{1.8}$$

$$N_I = \in I_{max}/\ \bar{h}_r\ \Delta t \tag{1.9}$$

$$N_k = \alpha\ \bar{h}_r^2\ \ \tau_{cy}/\ k2 \tag{1.10}$$

$$N_w = w_r/\ (L2\bar{h}_r\ \tau_{cy}) \tag{1.11}$$

$$N''_{q,o} = q''_o/\ \bar{h}_r\ \Delta t \tag{1.12}$$

$$N_{q,i} = q_i/\ (L^2 \bar{h}_r\ \Delta t) \tag{1.13}$$

$$R_h = R_h\,(X_j, T) = h/\bar{h}_r \tag{1.14}$$

$$R_I = R_I\,(X_j, T) = I/I_{max} \tag{1.15}$$

The above groups are also similarity groups. If they are the same for a prototype and its model, both will behave thermally in exactly the same manner.

1.2.2 DIMENSIONLESS FORM OF THE PROBLEM

Substitutuing the dimensionless groups of eqns (1.1) to (1.15) gives the dimensionless form of the problem as follows, in the same order

$$\nabla^2\ \Theta = \frac{N_B^2}{N_k}\ \frac{\partial \Theta}{\partial T} \tag{1.16}$$

$$\Theta\,(X_j, T) = \Theta\ (X_j, T+n) \tag{1.17}$$

$$\nabla\Theta .\ \bar{N}_0 = N_B\, R_{h,0}\,(\Theta_{\,0} - \Theta_a) - N_B\, N_I\, R_I - N_B N''_{q,o} \tag{1.18}$$

The general mathematical relations are stated in a general form, and the similarity groups are obtained by the so-called «differential method» [13]. The modeling of these groups is discussed here in some detail. It is shown that complete similarity is not necessary and two scales could be used, one for the general building and the other for the components thicknesses. On the other hand, methods for the physical realization of simulation conditions are not explored.

1.2 ANALYSIS

A temperature of a room depends on the outside air temperature and the intensity of solar radiation, both are functions of time It also depends on the properties and dimensions of the room walls, particularly the outside walls that are exposed to changing weather conditions of temperature and insolation Within a wall, the temperature is function of position and time and is governed by the general euation of conduction with appropriate boundary conditions

The problem is formulated as follows: The general equation of conduction for isotropic walls of constant properties is

$$\alpha \nabla^2 t = \frac{\partial\ t}{r} \tag{1.1}$$

For established-state conditions, a boundary condition of periodicity may be used, it is

$$t(x_j, \tau) = t(x_j, \tau + n\tau_{cy}) \tag{1.2}$$

where $j = 1,2,3$ and $n = 1,2,3,...$; and τ_{cy} is the period, 24 hours for the prototype.

For the exposed wall surface, the energy balance gives:

$$-k\ \nabla t.\bar{n}_0 = \in I + h_0 (t_a - t_0) - q_0^{\cdot} \tag{1.3}$$

Here, the emissivity $\in$ of the exterior wall is taken as its absorptivity, walls being practically grey surfaces. The incident solar radiation I and the outside heat transfer coefficient h_0 (which includes radiant loss) are both, in general, known functions of position and time. The symbol $q^{\cdot}_0$ stands for the part of flux density that arrives at the outside surface but taken away to be dissipated elsewhere, as that due to solar collectors or solar cells.

In a similar manner, the boundary condition for the inside surface of unknown temperature $t_i(x_{j,i}, \tau)$ would be

$$-k\ \nabla t.\ \bar{n}_r = h_r (t_i - t_r) \tag{1.4}$$

Here, again, h_r is, in the most general case, a known function of space and time. However, the room temperature t_r would be assumed uniform inside the room and vary with time only.

The heat convected to the room, as given by eqn (1.4) is used to change the temperature of the room air and contents, and supply any other internal load $q_i = q_i(\tau)$, as that of a heater or cooler. This term should include the direct solar flux through windows, etc., in which case it would be a negative quantity. Therefore,

$$\int_{A_i} h_r (t_i - t_r)\, dA_i = w \frac{dt_r}{d\tau} + q_i \tag{1.5}$$

1.1 INTRODUCTION

The prediction of the thermal load on a building is an old problem in the field of refrigeration and air conditioning [1 to 8][1]. It gained new importance lately with the rise of energy cost and the use of solar energy as a prime source for heating and cooling. These called for more accurate methods. For this purpose, a number of computer programs were developed to simulate the thermal behaviour of buildings [9][2]. Most of these programs use average daily temperatures to predict the thermal load on a whole building. There are also analytic methods to predict the thermal behaviour of, or load from, a building component [4 and next chapter]; they can give an hour-by-hour inside temperature of a building, or the heat fluxes across its walls.

While the analytic methods are accurate, they can only be used for buildings of simple construction; where the boundary conditions are manageable. When the boundary conditions in space and time become complicated because of the effects of nearby buildings, shading devices, etc., the analytic formulation of the problem becomes virtually impossible. In such cases, one method of solution is to carry out tests on actual prototypes [11]. Obviously such a method would be very expensive and needs a long time to obtain results that may not always be representative of typical installations, occupancy, etc.

Physical modeling is a viable method to predict the effects of passive control devices, or the heating and cooling loads on a building. In a simulation facility, various types of design, construction, loading, climate, orientation, etc. could be tested in a short period of time with reasonable accuracy and expense. In fact, modeling may be the only practical method for predicting the thermal behaviour of complicated and expensive structures.

A pioneer work in modeling seems to be that of Alexander [11].

However, the object of his work was to compare different frame constructions subjected to prototype conditions. The analysis made, based on steady-state conditions, are rather sketchy and qualitative.

To carry out physical modeling properly, the similarity groups that control thermal behaviour should be identified; this is done here by a method used by one of the authors [12] in a similar problem as follows.

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1. Numbers in brackets designate References at end of report. Those cited here are not the only ones in the literature, some of them [1,2,3,8] list other pertinent works.
2. This reference contains a number of papers that describe the methods used in different countries.

محسن يوسف الكويتي

Chapter I

GENERAL MATHEMATICAL FORMULATION AND THE PHYSICAL MODELING OF BUILDINGS

The contents of this Chapter were presented at the ISES 1979 International Congress, Atlanta, GA, U.S.A., May/June 1979.

combination of both) of the component thermal flux density or the building temperature. In the approach used, the effect of outside air temperature and of solar radiation are separated, and the soltuion gives their separate effects. This adds to the flexibility and generality of the solution because the effect of the outside air is the same for all orientations. Further, the solution is in terms of a Fourier series and, hence, consist of steady-state and periodic parts. The first part gives the average load on a refrigeration or air conditioning unit; hence indicates directly the total energy needed per cycle. The periodic part gives the maximum load on the unit and, hence, indicates its capacity.

The third chapter is an extension of the previous one to composite components; i.e. components that are composed of insulating and/or protective layers together with the load-carrying layer.

In the fourth chapter, the economics problem is formulated by defining the fixed and operating costs, and identifying them with the parts of the solution of the thermal problem. A method for the solution of this problem is then outlined to determine the component's optimum construction that gives the least total annual cost of component, cooling unit, energy, etc.

In the fifth chapter, a numerical example is solved to illustrate the method presented in Chapter 4.

Appendices contain, among other things, the computer programs used and the methods of their use.

INTRODUCTION

The era of cheap energy is past. It became clear that the classical sources of energy, particularly oil, are too precious to be wasted as fuel; they are the raw materials for important industries essential for the welfare of humanity. Being depletable, this fact resulted in the escalation of fuel prices in the recent years, and necessitated serious considerations for the preservation of these sources and their efficient use. Calls are abundant for the saving and wise use of fuel. However, experience has showed that people are usually slow in heeding such calls, and it would take quite a long time for them to realize the gravity of the situation and start active fuel saving. Concurrent with these calls is the active endeavour of tapping new sources of energy; however, the development of new technologies is a long process. For all these reasons, and until new technologies are established, man has to try to improve the efficiency of existing methods of power generation, and positively reduce energy consumption through new methods of design.

One of the promising sources of energy is the solar energy directly tapped. The sun, the fundamental source of energy available on Earth, is also a reason for its loss; it forms the main thermal load on buildings maintained at temperatures lower than those of their environs. Examples of such buildings are cold stores, air conditioned buildings in summer, etc. This made the determination of thermal load, on buildings due to the sun and surrounding air one of the important subjects of refrigeration and air conditioning. However, the conditions that prevailed recently, namely the low fuel cost relative to that of labour, seems to have made simplicity the main objective of calculating methods rather than accuracy. This was to avail these methods to technicians and non-engineers. The recent change in relative cost made it imperative to reconsider these design methods and replace them by more accurate ones that would permit economic studies to be carried out concurrently.

The following report is an attempt in this direction. In the first chapter, the general mathematical relations that govern the thermal behaviour of buildings are stated in general form. The similarity groups are then obtained by the so-called «differential method». The use of these groups gives more generality to a mathematical solution; they also give criteria for physical modeling of buildings which is a viable method for predicting heating and cooling loads and determining the effects of passive control devices for «solar houses».

In the second chapter, the one-dimensional problem is considered and a method of solution is presented for the determination of the thermal effect of a simple single building component (roof, wall, etc.). Although the problem treated is that of controlled indoor temperature and the solution is for the heat flux density, the formulation is quite general and could be solved for either passive or positive control (or any required

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PREFACE

This is the final report on the project entitled «Thermal Load on Air Conditioned Buildings and Its Optimization».

Originally, Dr. Ali El-Shibani participated in this project. After the completion of the contents of the second chapter, his new commitments after his transfer from Al-Fateh University made his further participation in the project practically impossible. The project was, therefore, completed without the benefit of his cooperation.

This report is presented in two parts: the text and the appendices. The latter are quite voluminous as they contain data called for in the project; they are not, however, essential for following the text contents.

CENTER FOR SOLAR ENERGY STUDIES

National Academy For Scientific Research

THERMAL BEHAVIOUR OF BUILDINGS

DETERMINATION AND ECONOMICS

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